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ELECTRON-ELECTRON COLLISIONS IN THE PRIMARY ENERGY RANGE FROM 1.3 TO 2.6 MILLION ELECTRON VOLTS

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ABSTRACT

The absolute value of the electron-electron scattering cross-section is studied by observing the production of energetic side branches by primary electrons of kinetic energy T_p. The quantity measured is the number of side branches with energy greater than a chosen value, T_0, and less than $0.5T_p$. We employed 343 meters of electron track, with primary energy between 1.3 and 2.6 MEV. The observed numbers of side branches agree with those calculated by Möller's formula, within the limits of error due to experimental difficulties and statistical fluctuations. The ratio, R, of the observed and calculated cross-sections comes out as follows:

T_0 in EKV	R
20	1.07 ± 0.09
30	0.99 ± 0.11
40	1.04 ± 0.12

The Möller formula is essentially correct for the primary and secondary energy ranges considered here.

I. INTRODUCTION

THIS paper is concerned with absolute measurements of the electron-electron scattering cross-section. The problem is to determine the number of side-branch electrons with energy greater than some arbitrary value, T_0, which are produced per unit length of the track of a fast primary electron. There are two methods for measuring the amount of energy transferred in such electron-electron collisions, occurring in the gas of a cloud-chamber. The first is to determine the energies of the side branches, or secondaries, by measuring their ranges. When the energy of a secondary is 20 electron kilovolts, its range in air at normal temperature and pressure is about 8 millimeters. In this paper secondaries with energies equal to or superior to 20.3 EKV are studied. Since the range-energy relation is accurately known from experiments for the range 20 to 60 EKV, this method has been employed for the work about to be described. The second method of investigating electron-electron collisions, used by Champion,[1] is to measure the curvature of the primary track and the angle, θ, through which it is scattered in the collision process.

Prior to recent work by Hornbeck and Howell[2] in this laboratory, the experimental findings were in a contradictory state and covered only a restricted range of primary energies, as we shall see below. The present investigation is a continuation of their work, with the objectives of decreasing the statistical errors and of increasing the accuracy of all the measurements involved.

A. Theory.—We are now in possession of a relativistic theory of the electron-electron cross-section which should yield correct results if the Coulomb law of force is correct at all distances. This theory, due to Möller,[3] includes the effects of exchange and retardation of potentials, to terms in $(v_p/c)^2$, inclusive, v_p being the velocity of the incident electron. J. J. Thomson gave a formula for this quantity on the basis of non-relativistic mechanics. What we require here is the cross-section, $S(T_1, T_2)$, for an energy transfer between T_1 and T_2. If an electron of kinetic energy T_p and velocity v_p strikes a free electron at rest, the result is

$$S_c(T_1, T_2) = \frac{2\pi e^4}{m v_p^2}\left(\frac{1}{T_1} - \frac{1}{T_2}\right), \qquad (1)$$

where e is the charge, and m the rest mass.

In the range of secondaries considered here, and for scattering in gases of low atomic number, corrections for the kinetic energy and binding energy of the atomic electrons are negligible. A side branch of energy T may be formed either by an atomic electron or by a primary which has lost energy $T_p - T$. Since it is impossible to distinguish between these cases, we agree to designate the energy of the slower electron at T. Thus, T is always less than $T_p/2$. As a convenient mode of speech, the branch of higher energy will be called the scattered primary, and

* Now at Naval Research Laboratory.

[1] Champion, *Proc. Roy. Soc. A*, **137**, 688 (1932).

[2] Hornbeck and Howell, *Proc. Amer. Philos. Soc.*, **84**, 33 (1941).

[3] Möller, *Annalen der Physik*, **14**, 531 (1932).

the branch of lower energy will be called the secondary. With these conventions, the cross-section for the production of a secondary with energy greater than T, according to classical mechanics, is

$$S_c(T, T_p - T) = \frac{2\pi e^4}{m v_p^2}\left(\frac{1}{T} - \frac{1}{T_p - T}\right). \quad (2)$$

On the basis of non-relativistic theory there is no upper limit to v_p, and for relativistic values of T_p, formula (2) differs widely from Möller's formula. However, if we use for v_p the correct value instead of the non-relativistic one, formula (2) becomes a fairly good approximation to Möller's result over the whole energy domain considered here, and it is very useful in making rough estimates of the cross-section. As v_p approaches its limiting value, c, the cross-section becomes practically independent of T_p. For convenience, we introduce the symbol $A = T/T_p$. (*If* the two electrons were distinguishable, this would be the fraction of the kinetic energy transferred to the secondary.) The cross-section (2) decreases with an increase in A, becoming zero for A equal to 0.5; because of the convention above, there are no "secondaries" with energy greater than $0.5T_p$. Primary and secondary energy ranges that permit cloud-chamber studies are, therefore, limited, and it is necessary to choose ranges such that a reasonable number of events suitable for measurement can be accumulated.

Möller's more exact formula applies when T is large compared with the binding energy of an atomic electron and small compared with T_p, so it is suitable for use in discussing the present results. Integrating his differential cross-section from an arbitrary lower limit T_0 up to $T_p/2$, the cross-section for production of a branch with energy between these limits is

$$S(T_0, T_p) = \frac{2\pi r_0^2}{\beta_p^2 T_0}\left(\frac{1 - 2A_0}{1 - A_0}\right) \times \left[1 - (1 - g)A_0\frac{1 - A_0}{1 - 2A_0}\log\left(\frac{1 - A_0}{A_0}\right) + gA_0(1/2 - A_0)\left(\frac{1 - A_0}{1 - 2A_0}\right)\right]. \quad (3)$$

Where $\beta_p = v_p/c$; $A_0 = T_0/T_p$; $g = (\gamma - 1)/\gamma^2$; $\gamma = (1 - \beta_p^2)^{-1/2}$, and $r_0 = e^2/mc^2$. Here the energy is in mc^2 units, and the constants employed are the same as those used by Hornbeck and Howell, viz., $2\pi r_0^2 = 4.983 \times 10^{-25}$ cm^2, and 1 mc^2 unit = 0.5113 MEV.

The expression outside the square brackets is equivalent to Thomson's formula, if the above mentioned relativistic correction for the change of mass in velocity is made in the latter. The second and third terms in the bracket represent the effects of retardation of potentials and quantum-mechanical corrections. For the range of A-values employed in this work, these two terms alter the cross-section only about 1.3 per cent.

B. Previous Work.—Employing the second method mentioned above, Champion studied the distribution in angle of beta particles scattered by electrons in nitrogen gas, covering the primary energy range from 0.4 to 1.1 MEV. For most of the 250 events studied, however, the primary energy was less than 0.66 MEV. The observed number of branches was 8 per cent lower than the number predicted by Möller's formula, a satisfactory agreement, considering statistical fluctuations.

Williams and Terroux[4] investigated the secondaries produced on 18 meters of track in oxygen, by primaries having energies from 0.13 to 1.6 MEV. In their work the total number of branches with energies greater than 7.5 EKV was 72. In comparing the data with the predictions of Thomson's formula, the only one available at that time, the ratio, R, of the observed number of events to the calculated number was used. In going from the lower limit of the primary energy to the upper limit, the value of R increased from 1.4 to 2.8.

Hornbeck and Howell, desiring to explain the large discrepancies between the results of Champion and of Williams and Terroux, studied secondaries produced by electrons of energy between 0.7 and 2.6 MEV. Their work was divided into two parts. First, the effect of primary energy upon the cross-section was studied; the energy of each primary was measured, and secondary energies, from 12 EKV up to the highest value encountered, were determined by range measurements. The results show that in the range they covered, the cross-section varies only slightly with primary energy.

In the second part of their investigation, pri-

[4] Williams and Terroux, *Proc. Roy. Soc. A*, **126**, 289 (1929–1930). See also Howell and Hornbeck's discussion of an interesting experiment carried out by Williams, *Proc. Roy. Soc. A*, **128**, 459 (1930), using primaries of energy 20 EKV.

mary energies were measured only when there was doubt as to whether the primary was in the region being studied. In order to reduce the percentage error in range measurements, only secondaries with energies greater than 20 EKV, or range greater than 0.8 cm, were included. The results are shown in Table II, together with our own data. A value of R in Table II is the ratio of the number of events observed to the number calculated by formula (3). The limit of error given with each value of R is the standard deviation associated with the random occurrence of secondaries along tracks; it does not include any allowance for instrumental or personal errors. The data, in the second column of Table II, indicate a slight excess of observed events over the number calculated by the Möller formula for low values of T_0. Hornbeck and Howell mention two systematic errors which would increase the value of R. They are: (1) inclusion of slow stray electrons, occurring on or near the primary track, some of which cannot be distinguished from genuine secondaries; and (2) inclusion of tracks which are formed before the chamber expands, when the gas is 1.13 times as dense as it is after the expansion. They estimate that these errors could cause a spurious increase of about 2.8 per cent in the observed cross-section. Table IV gives results corrected for these errors. They also discuss random errors and systematic errors of unknown sign which could cause a resultant error of about 7 per cent. They conclude that their data substantiate the essential correctness of the Möller formula and indicate that the results of Williams and Terroux cannot be correct. According to a private communication from Professor Williams, the same conclusion has been arrived at by Williams and Cameron, from unpublished results which place the value of R at 1.2.

C. Nature of the Present Work.—The present work is a continuation of the second part of the Hornbeck-Howell experiments. It is an endeavor to check more accurately the cross-section for electron-electron collisions in the primary energy region from 1.3 to 2.6 MEV. In the work of both Williams and Terroux and Hornbeck and Howell, it was found that the values of R were greater than one for low values of T/T_p and slightly less than one for high values of this ratio. The following influences, to varying degrees, may be responsible for this: unfavorable statistical fluctuations in the occurrence of events; inclusion of slow electrons produced in the gas so close to the track that they cannot be distinguished from bona fide secondaries; inclusion of pre-expansion tracks; inaccuracy in range measurements; straggling of secondaries; and errors in the range-energy curve. It is desirable, therefore, to have a larger body of data with special emphasis placed on high values of T/T_p, in order to reduce the statistical fluctuations to a value comparable with, or less than, the resultant experimental errors. Improvements in the technique of measuring ranges of secondaries and in the criteria for selecting tracks have been attained. Also, we have determined more accurately the corrections for the two systematic errors mentioned above, by observations more extensive than those of Hornbeck and Howell. In this way, the influence of these two systematic errors on the final results can be practically eliminated.

II. Technique

A. Measurement of Energies.—As in the work of Hornbeck and Howell, the primaries were recoil electrons produced in the walls of a nitrogen-filled cloud-chamber, by gamma-rays from a well-aged mesothorium source. As in their case, our measurements were made on a large collection of photographs taken by Dr. C. C. Jones, in a field of 1200 gauss. The stereoscopic viewing apparatus described by Jones and Ruark[5] was employed. Primary energies were determined by radius measurements, and secondary energies were obtained from ranges by means of von Droste's[6] curve, based on all data, for several gases, available up to the time of his paper. It covers the range of energies up to 50 EKV. The inaccuracies in this curve are thought to be less than 4 per cent for reasons explained by von Droste and by Hornbeck and Howell.

Two methods were employed for measuring ranges. We used a glass centimeter scale for those tracks which were nearly straight and nearly in the plane of the ground glass viewing screen. The method for measuring the component of the track length perpendicular to the screen has been described by Jones and Ruark. For secondaries which experienced abrupt changes in direction, or which consisted of spirals of short radii, or which were otherwise difficult to measure, a piece of No. 27 bare copper

[5] Jones and Ruark, *Proc. Amer. Philos. Soc.*, **82**, 253 (1940).

[6] von Droste, *Z. Phys.*, **84**, 17 (1933).

wire was placed on the screen and bent into the shape of the projected track-image. Thus, it became, as nearly as could be determined, a replica of the projected image. The wire was held on the screen while viewing the track image stereoscopically, and thus if the image was not in the plane of the screen, the wire still could be made to approximate the shape of the track. By straightening the wire one could get an accurate measurement of the projected length. If the component of track length perpendicular to the screen was appreciable, it was, of course, determined. The wire method is more accurate and more objective than that used by Hornbeck and Howell, in which the track length was approximated by a series of chords. In their measurements the scale itself was applied to the track image. If the energy happened to lie near the boundary of two secondary groups, there might be a personal tendency to put the track in one group rather than the other. In our method, the length of the projection is unknown until after the wire has been applied and its length has been measured. Since errors in the range measurements are important, especially for 20 EKV branches having a length of about 0.8 cm, each secondary was measured independently at least twice, by each of two observers. Where the results of the two observers were in close agreement, the average of the results was taken. In the few cases in which, due to complex shape or unfavorable position of the secondary, the two results did not agree within 5 per cent, the measurements were repeated at least three times by each observer, and an average of the several measurements was taken. Of course, this careful repetition was necessary only when the secondary was near the boundary of an energy group. To make the final results still more objective, no summary of the secondaries or calculation of the expected number of events was made until all measurements were complete.

B. Criteria for Selection of Tracks.—In spite of precautions in taking the electron photographs obtained with a gamma-ray source, some diffuse pre-expansion tracks and some weak post-expansion tracks due to "late" electrons, will always be present. Some tracks will lie in regions unfavorable to accurate measurement and should be excluded. It is essential to adopt objective criteria as to the inclusion or exclusion of tracks before the measurements are begun. Such criteria should be so chosen that the number of decisions required is reduced to a minimum. Our criteria, which differ somewhat from those of Hornbeck and Howell being based on their experiences and difficulties, were as follows:

1. Only primaries which have h/c less than 0.3 were taken; where h is the distance parallel to the field, between the ends of the measured arc of the track and c is the chord length. Only a few tracks were excluded by this criterion. Since the length of a track having h/c less than 0.3 differs only slightly from the length of its projection on the ground-glass viewing screen, very little error would be incurred even if no correction were made for this difference between the true length and the projected length. However, measurements were made on 150 tracks in order to determine the magnitude of this error, and finally a correction was applied to the total projected track length.

2. In order to minimize errors in total track length, no primary of length less than 5.0 cm was taken.

3. To minimize the percentage of pre-expansion tracks included and to increase the accuracy of the curvature measurements, tracks the images of which on the viewing screen were wider than the arbitrary value of 0.8 mm were excluded. The width was compared with a standard ink line ruled on a transparent sheet.

4. Portions of primaries which were obscured by other tracks so that secondaries might be missed entirely, or misinterpreted, were not included. The application of this criterion was not often necessary; however, to avoid the inclusion of tracks which might falsify the results, the pictures were first projected non-stereoscopically in quick succession, and the frames containing obviously undesirable clusters of tracks were eliminated.

5. In the case of primaries which became gradually faint within 2.5 cm of the chamber wall (distance measured perpendicular to the wall), the track was considered to extend to the wall, for it is probable that any slow secondary produced in this region could be detected because of its density of ionization, in spite of the slight defect of vapor density responsible for the faintness. To get an estimate of the error that could be incurred if this assumption were partially erroneous, the sum of the lengths of these faint portions was found for 100 meters of track. The added track length due to their inclusion was only about one-half per cent of the total. Tracks that became faint farther than 2.5 cm from the wall were included, but only the portions that could be distinctly seen were used; these tracks constituted less than one per cent of the total track length.

6. The primaries and secondaries must be of the same age, as far as can be determined visually.

7. The length of a secondary was measured from the middle of the primary track to the center of the droplet or cluster of droplets on the end of the secondary.

III. Results

The theoretical cross-section changes only about 1.3 per cent, as one varies the primary energy over the entire range studied here, but to increase the accuracy of the calculated values as much as possible, the energies of 200 tracks were measured in order to determine the energy spectrum for this body of data. The tracks were divided into four energy groups and a hodograph was plotted showing the fraction of the total track length lying in each energy group. The results of the survey are shown in Table I. The

TABLE I

Primary Energy Spectrum

Energy Group MEV	Fractional Part of Total Track Length in Group
1.30–1.64	0.322
1.64–1.98	0.443
1.98–2.32	0.182
2.32–2.60	0.053

theoretical cross-section is a weighted mean calculated by means of this hodograph.

On a total of 343 meters of primary track, 180 secondary electrons were found. In presenting results of this kind, the events can be classified in either of two ways. One may count the number of secondaries with energies in certain arbitrary domains, T_1 to T_2, T_2 to T_3, etc. Alternatively, one may count the number of secondaries with energies superior to T_1, T_2, and T_3 (equal to 20.3, 31.4, and 42.2 EKV in this work) respectively. We have used the latter method for a reason made clear by the following example. If a secondary with energy of 30 EKV were wrongly assigned to the group 31.4–42.2 EKV, the error would take double toll, so to speak, for the numbers in the group 20.3–31.4 and 31.4–42.2 EKV would both be falsified. However, using the second plan, the number in the group "20.3 EKV and up" would not be affected by this error; furthermore, the percentual effect on the group "31.4 EKV and up" would be smaller than the effect on the group 31.4–42.2 EKV employed in the first method of presentation. Accordingly, Table II shows the number of secondaries having an energy greater than a chosen lower limit T_0, as a function of this limit. Due to slightly different electron densities, our limits of energy are slightly different from those of Hornbeck and Howell. The

TABLE II

Variation of R with Energy of Secondaries

Author	Lower Energy Limit (EKV)	Calculated No. of Events	Observed No. of Events	R
Hornbeck-Howell	20.5	88.3	107	1.21±0.12
	31.6	56.4	63	1.12±0.14
	42.7	40.9	35	0.86±0.15
Shearin-Pardue	20.3	162.0	180	1.11±0.08
	31.4	103.3	105	1.02±0.10
	42.2	76.0	81	1.07±0.12

uncertainties assigned to the R-values are those due to statistical fluctuations alone.

IV. Discussion of Results

The more important errors encountered are as follows:

1. *Strays.*—We studied all stray electrons produced in the gas of the chamber, occurring in several frames of each film used in the present work. It was assumed that one could distinguish between a stray and a bona fide secondary if the stray lay entirely outside a cylinder of 2 mm radius around the primary, a liberal estimate. For a secondary of energy greater than 40 EKV, one can ordinarily tell from its curvature, whether it ends or begins on the primary, thus reducing by one-half the value of the error in this energy range. Also, the deflection of the primary can be observed for secondaries of energy greater than 30 EKV, unless the secondary is ejected in a direction nearly parallel to the line of sight. Furthermore, each genuine relatively slow secondary should leave the primary nearly at right angles; in practice it may be scattered close to the primary, but occasional troubles in recognizing a true secondary caused by such scattering, will be pronounced only for branches in the energy range 20–30 EKV. Taking these factors into consideration, all strays in the frames studied were counted and classified according to their energies. The number of strays, N_s, with energies lying within a given energy range, to be expected on the average track length found in one frame, is given by

$$N_s = N(v/V), \tag{4}$$

where v is the total volume of cylinders 2 mm in radius surrounding the tracks on one frame; V is the volume of the cloud-chamber; and, N is

the number of strays, in the given energy range, per frame. Table III shows the results.

TABLE III

Lower Energy Limit of Group (EKV)	Percentage of Spurious Secondaries
20.3	1.49
31.4	0.66
42.2	0.41

2. *Pre-expansion Tracks.*—Hornbeck and Howell estimated that the error in the cross-section due to the inclusion of pre-expansion tracks is less than 3 per cent. The error is probably about 2 per cent, and is such as to increase the value of R.

3. *Range Errors.*—Range measurements for secondaries near the lowest energy limit are more difficult to make than those at the other limits; thus the personal and instrumental errors in measurements at the lowest energy limit are greater than those at the other limits. We believe that in measuring an individual 8 mm track the average error is not more than 0.4 mm. This would give a maximum error in the cross-section of unknown sign, amounting to 2.5 per cent. Even if a systematic error of 0.4 mm existed in the case of all branches belonging to the group for which T_0 is equal to 20.3 EKV, the error in the measured cross-section could be only 2.5 per cent. Considering the compensation due to the random nature of the errors in range measurements, a liberal estimate of the effect on the cross-section is 1.5 per cent.

4. *Straggling Errors.*—Calculations were made to estimate the error in the number of events observed in a given energy range, due to straggling of the secondary electrons. For the purpose of this calculation, the 20.3 EKV limit was considered. Assuming that the electrons of a given energy follow a Gaussian distribution, with a half-width at half-maximum amounting to 26 per cent of the range, the total number of secondaries with energies less than 20.3 EKV, that would have ranges greater than the mean range, R_0, for 20.3 EKV electrons, was calculated numerically. Likewise, the number of secondaries of energy greater than 20.3 EKV but with ranges less than R_0 was calculated. Formula (1) was used to determine the expected number of secondaries in a range dT; the relativistic values of v_p and T_p were employed. The results show that for the 343 meters of track considered here, 9.2 electrons with energy less than 20.3 EKV should be affected by straggling in such a way that they would be attributed energies greater than 20.3 EKV; 9.0 electrons with energy greater than 20.3 EKV should be attributed energies less than that value. Because of this compensation, the systematic effect of straggling on the cross-section should be negligible in our work. If the very unfavorable case were taken, in which 9.2 events straggled to lower energies, the error in the observed cross-section would be 5 per cent. We believe 2 per cent is a liberal estimate for straggling error.

5. *Range Energy Curve.*—We believe that the error in energies read from this curve is less than 4 per cent.

To summarize, we have discussed five important sources of error. The personal and experimental error in measuring the ranges of the secondary electrons, the straggling error, and the error in the range-energy curve are of unknown sign; compounded in the usual way, the resultant is 4.7 per cent. The systematic errors due to inclusion of stray events and pre-expansion tracks can be subtracted. The results, after correction for these two errors, are shown in Table IV, together with comparable values given by Hornbeck and Howell. The limits assigned are the resultants of fluctuation error and instrumental and personal errors of unknown sign.

TABLE IV

CORRECTED RESULTS

Approximate Lower Energy Limit (EKV)	R Hornbeck and Howell	R Shearin and Pardue
20	1.18±0.14	1.07±0.09
30	1.09±0.16	0.99±0.11
40	0.84±0.17	1.04±0.12

Of the work preceding this paper, only that of Hornbeck and Howell will be discussed here in connection with our results, because the results obtained by Williams and Terroux have been shown to be erroneous, and Champion's results, for much lower primary energy, are in fair agreement with theory. As pointed out above, several improvements have been made over the Hornbeck and Howell experiment by taking advantage of their experiences and difficulties. These improvements have enabled us to obtain

results that should be more accurate than theirs. A part of the discrepancy between the Hornbeck and Howell results and theory is probably due to unfavorable statistical fluctuations, particularly in the case of the second and third energy groups where the value of R is based on a small number of events. Their results and our own do not indicate any definite failure of theory when the possible errors, statistical and instrumental, are considered. The decrease in the R-values as T_0 increases, found by Hornbeck and Howell, does not appear in our results. We conclude that the Möller formula is essentially correct for the ranges of primary and secondary energy we have covered. We wish to emphasize the importance of thorough tests of this formula, the only one in which the interaction of two similar fundamental particles has been calculated with perfect symmetry, in accordance with the spirit of Breit's considerations.[7] Experiments for much higher values of T_0/T_p, and for T_p values in the cosmic ray domain, are being prepared, but will be time-consuming. We express our appreciation to The American Philosophical Society for a grant to Dr. Arthur E. Ruark which made this work possible, and to Dr. Creighton C. Jones for permission to use the photographs from which these measurements were made. We are grateful to Dr. Ruark for discussions of theory and of the experimental procedures.

November 7, 1941

[7] *Phys. Rev.*, **34**, 553 (1929).

THE MICROSCOPY OF MAMMALIAN HAIR FOR ANTHROPOLOGISTS*

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ABSTRACT

An attempt is made to develop a technique for identifying hairs and wools from various types of materials recovered during archeological work in North America and primarily in the Southwest. In this first section keys, brief descriptions and drawings are presented for all of the genera of *Carnivora* found north of the Mexican border. These aids are not proposed to surplant direct comparison with known material but to aid the archeologist in selecting material for comparison.

INTRODUCTION

NUMEROUS studies of the microscopy of human hair have been made for the use of anthropologists. With continued refinement of techniques these studies have tended to eliminate any necessity for microscopic examination of human hair specimens in routine anthropometry. While it may prove that there are differences that set apart the various races and sub-races that may be based upon the microscopy of hair, it has been fairly well proven that the race of an individual cannot be determined with certainty from the microscopic structure of the hair. Kneberg [1] has shown the old idea that the texture of the head hair was definitely associated with the cross-section index to be erroneous. She has also demonstrated that the form of the cross-section is not a racial characteristic. Hausman [2] had previously shown that the cuticular scales and medullary structure are directly related to the diameter of the hair shaft, and his student, Miss Wynkoop,[3] has shown that age has little or no bearing on the microscopic structure. Work under way by the present author seems to indicate that there is little additional information gained from a microscopical examination of hair gathered from ten different parts of the body of a "normal" individual. Thus, so far as man is concerned, the anthropologist need pay little attention to other than the gross aspects of the hair. There may be some benefit derived from the study of the microscopic structure of pathologic hair. This is being investigated by several workers.

The microscopy of the hair of other mammals may be a very useful tool for the archeologist and ethnologist. Primitive peoples have used wool derived from many sources and bits of fur have been extensively employed by them. It is of interest to know the animal source of the hair and hide so employed. To my knowledge there has been no lengthy paper devoted to the microscopic structure of hair from a taxonomic point of view other than Glaister's.[4] Unfortunately the value of this contribution is negated by the poor reproductions illustrating it. Many of Hausman's papers are helpful and contain considerable material but none of them may be used as a basis for the determination of the source of a hair sample.

For the past twenty years I have dabbled with the micro-structure of hair from a taxonomic stand-point. Most of this was purely to satisfy a personal curiosity. More recently I have been called upon to determine the sources of samples of yarns recovered from archeological sites and a variety of other materials of ethnic value. Three years ago through the encouragement of Dr. A. V. Kidder of the Carnegie Institution and with partial financial aid from the American Philosophical Society I embarked upon this venture. At the beginning I had hoped to be able to reduce to a purely objective study the technique for determining the species from which a given group of hairs came. In other words to build a simple key to the characteristics. In this I have been only partially successful. While the keys may function properly for me I have no illusion that they are universally good. The keys may help eliminate some genera but the only certain way to study an unknown is to compare it minutely with material from known sources. The drawings which have been pre-

*Supported by a grant from the Penrose Fund of the American Philosophical Society.

[1] *Amer. J. Phys. Anthrop.*, xx, 51–69, 1935.

[2] *Amer. J. Phys. Anthrop.*, viii, 173–178, 1925.

[3] *Amer. J. Phys. Anthrop.*, xiii, 177–187, 1929.

[4] "A Study of Hairs and Wools Belonging to the Mammalian Group of Animals, Including a Special Study of Human Hair Considered from a Medico-Legal Aspect." Egyptian University. Faculty of Medicine; Publication no. 2. Cairo-Misra Press; 1931, pp. 188, 145 pl.

pared for every genus of mammal found north of the Rio Grande—except the *Pinnepedia* and *Cetacea*—will further help to limit the possibilities in the identification of material of unknown source.

Techniques

The techniques employed for preparing a sample are simple. The specimen is first washed in alcohol-ether, dried, and then cleared in xylol for balsam mounting or mounted dry without clearing. For dry mounting I find small strips of Scotch Tape very convenient for fastening the cover-glass to the slide. Dry mounted slides are best for the study of the cuticular scales, balsam mounts for the medullary structure and pigmentation. Unless the cells of the medulla are impregnated with balsam that region will defy study. Impregnation will be assured if one or two hairs are cut into short lengths. Drying the slides in an oven at 37–40° C. is very helpful. A 40× objective worked with a 10× ocular is an admirable combination for most study. Occasionally oil-immersion is necessary for the study of pigment granules. While transmitted light such as is necessary for the study of the medulla and pigment will occasionally detail the scales, a beam of light from one side and just above the horizontal is best suited for their study. It is often helpful to use a lower powered objective and higher powered oculars for the scales since that will give a better depth of field.

The Structure of Hair

Reduced to the simplest terms hair is a tube. The walls of the "tube" are solid and termed the cortex, the bore of the "tube" is called the medulla and is usually filled with air cells. The outer surface of the "tube" is sheathed with overlapping scales called cuticle. In cross-section hairs present a variety of forms from circles to strongly flattened elipses or elongate ovals, or they may be triangular or polygonal. These forms do not seem to be constant and with a few possible exceptions are probably of no taxonomic value. The cross-section of a single hair shaft may be quite variable or it may be reasonably constant throughout its length. Certain externally applied pressures will change the shape of the cross-section, *i.e.* twisting for yarn or compression in an envelope. Most hair shafts show some variation in diameter throughout their length. The base is usually of less diameter than the mid-section and the tip may taper off to practically nothing or be blunt. The greatest diameter may be approached gradually or within a very short distance. Reference to Figs. 1 to 3 will visualize some of the changes found throughout the length of the shafts of some hairs. All of these figures are drawn from measurements taken from actual specimens. The first is a "normal" hair from the back of a Black Bear. The second is a type found in the *Cervidae*. The specimen is from the flank of a Pronghorn and shows the modified structure to a high degree. This will be further discussed in dealing with *Antilocapra*. The third figure represents a condition common among the *Mustelidae* and developed to a high degree in the Otter, *Lutra*. References to diameter in the text are made to definitely stated regions—usually the base or the widest portion of the hair.

The scales of the cuticle are of considerable importance in the taxonomic study of hair. The nomenclature for the various forms of cuticular scales was established by Hausman.[5] It needs no further embellishment for this paper. The ratio of the length of the free proximo-distal portion of the scale and the diameter of the shaft is called the scale index, $\frac{F}{D}$ = S.I. This

[5] *Amer. Nat.*, **44**, 496, 1920.

Figs. 1, 2, 3.

index usually varies inversely with the diameter. So scale indices may be applied only when hairs of the same diameter are being compared. The indices may be of some taxonomic importance but are so variable that this is yet to be fully established. The indices stated in the text are averages taken over a distance of 400 microns along the margin of the optical section (Fig. 4).

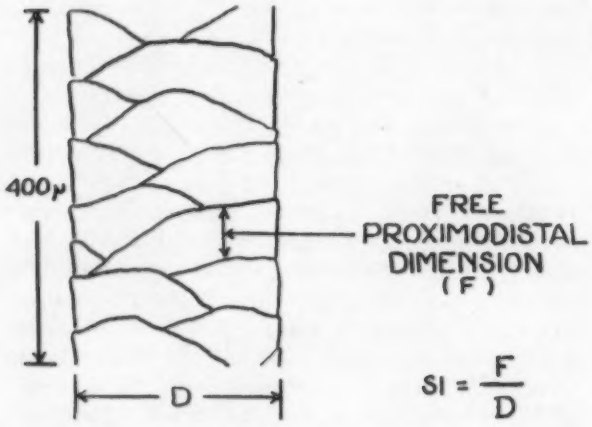
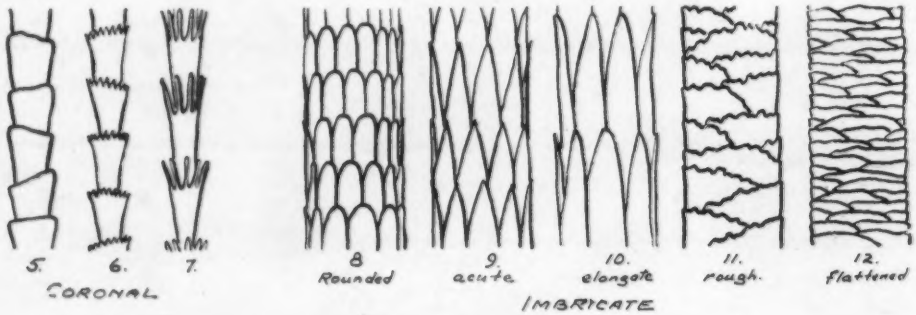


FIG. 4.

The types of cutic scales, after Hausman, are shown in Figs. 5 to 12 and little further description is necessary. Coronal scales, a peculiar form which completely encircles the shaft, are characteristic of the *Chiroptera*. They are found rarely in the other orders and then only on the thinnest fur hairs and not then are they the dominant form. The outline of the free margin of the scales is often helpful taxonomically as is the mode of imbrication. Occasionally the scales are pigmented.

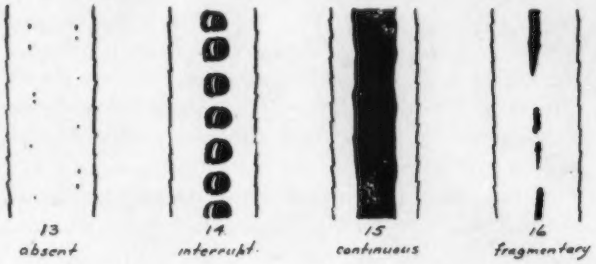
The cortex of the shaft constitutes its real body. Hairs in which this portion constitutes a minor part of the diameter are usually brittle—the hair of the deer is a good example of this. An extremely thin cortex plus a medulla filled with large cells is characteristic of some of the *Artiodactyla*, especially the *Cervidae*, etc. The proportion of the shaft occupied by cortex and medulla varies throughout the length of the shaft but within limits is constant enough for a given region to be of considerable diagnostic assistance. At the extremes of the hair shaft the cortex may compose the entire shaft. In rather rare instances this is true throughout the shaft. Within the cortex occur granules of pigment, the size, shape and frequency of which are of importance for the diagnosis of certain genera and species. There may also be a diffuse stain with or in lieu of pigment granules. Not to be confused with pigment granules are tiny "flaws," elongate air bubbles, called fusi. To the practiced eye these are not difficult to recognize. They occur more frequently in the hairs of some species than of others.

The medulla is usually filled with thin-walled cells of air. These cells vary a great deal in size and shape. Their general appearance is a helpful taxonomic character. They may be globular or flattened, they may be remarkably uniform or quite irregular or varied. They may extend completely across the medulla or only part way. They may appear to be loosely or closely packed. They may be so compressed as to appear like thin plates. When they are filled with air they make the medulla appear black under the microscope. Their full study requires that they be impregnated with the mounting medium. Pigment granules may or may not be present in the medulla. The granules may be in the cells but much more frequently they are packed into the interstices of the air-cells. The characteristics of the pigmentation are worth noting. Many of the *Rodentia* are immediately recognizable by it.



FIGS. 5–12. Types of cuticular scales.

The form of the medulla is of importance in some genera, Figs. 13 through 16 show the four major types, after Hausman.



FIGS. 13–16.

THE TYPES OF MAMMALIAN HAIR

Broadly all hair can be divided into two classes. These are the protective hair and fur hair. The coarse, outer-hair is called the protective hair and the fine, often woolly, underhair is called the fur hair throughout this paper. It is always to the advantage of the investigator to have bits of both types in exploring the possibilities of an unknown. Certain other, rather specialized kinds of hair are to be found on mammals—whiskers, bristles, mane and tail, and quills. These are not included in this paper. Their occurrence in the handicraft of primitive America is restricted to the easily recognized quill of the porcupine and recently the use of the tail hairs (and probably mane hairs) of the domestic horse.

PROCEDURE FOR EXAMINATION

Perhaps it is not amiss to insert at this point a brief outline of the procedure that I use in examining an unknown. A careful study of the gross aspects of the sample will usually eliminate many genera. For instance, with few exceptions, hairs an inch or more in length are not found among the *Rodentia*, while among the *Artiodactyla* hairs under an inch in length are equally rare except on the face. The color of the hair will often open up a lead but this is one to be followed with caution since many species bear hairs of a variety of colors. After gathering as many leads for the gross examination as possible I turn to the prepared slides and examine the balsam mounts first. These I examine *in toto* and note the general structure of the medulla, the gross diameter at the widest part of the specimen and the diameter of the medulla at the same point. At this time I also pay close attention to the shape of the longitudinal section. In general this will help in allocating any specimens from the *Carnivora* and especially from the *Mustelidae*. I also measure the scale index at this time as already outlined (see Fig. 4). Next I turn to the dry mounts and using flat, reflected light in place of the usual transmitted light study the contours of the scales. These are usually more easily studied in the basal regions of the hair shaft than the distal. This completes my first microscopic examination.

The data accumulated in the first study I use to select the slides of known material for comparisons. On pages 254, 255 I have gathered the information regarding the *Carnivora* of North America that will be useful in making these selections for that group. When the probabilities have been reduced to three or four genera I then carefully check through the data I have concerning them and the unknown with the aim of further elimination. Finally I compare the various parts of the unknown with the same parts of a specimen of known origin and approximately the same diameter. Such an examination is best done with a comparing microscope. This will usually eliminate all but one genus. Determination to species is then carried out in a similar manner but is often very difficult.

ACKNOWLEDGMENTS

I bring these introductory remarks to a close with a feeling of debt to many people. Dr. L. A. Hausman's pioneering in the field and his careful development of a standardized nomenclature for the structures of animal hair leaves all who carry on further work with a great respect for his studies and published papers. I owe a personal debt of thanks to Dr. E. R. Warren, who has freely given me access to his extensive collection of western mammals, to Dr. A. M. Bailey and his staff at the Denver Museum and to Dr. Herbert A. Anthony and his staff at the American Museum of Natural History for assisting me in filling out the series of samples necessary for this study. I cannot omit from this group Miss Georgia Minshall[6] who prepared over 6000 slides for this study and who undertook to work out the characteristics of the hairs of the *Artiodactyla* as part of her work for her Master's degree at Colorado College.

This, the first of a series of similar papers, is devoted to the *Carnivora*. I have broken away

[6] Now Mrs. H. Weston Robbins.

from a pure taxonomic order of treating the orders of mammals since the majority of specimens that I have been called upon to pass judgement on are either from the *Carnivora* or *Artiodactyla*. These will be treated first and the orders that seem to be of less importance to anthropologists later. Within the groups taken up I have and will maintain strict taxonomic sequence and follow Anthony in his *Fieldbook of Mammals*. This handy volume should be in every anthropologist's kit if he plans to make any studies relating to the fauna associated with a recent culture.

CARNIVORA

The carnivores range throughout the entire area covered by this paper. They are represented by twenty genera divided among six families. It is probable that the aborigines used the fur of most of them.

Both protective and fur hairs are always present. There is a great range in the length of the hairs from the shaggy pelage of the *Ursidae* to the smooth coat of some of the smaller *Mustelidae*. Generally speaking the protective hairs are widest distad of the mid-region. In some genera the taper is abrupt (*i.e. Lutra*) in others almost imperceptible (*i.e. Ursus*). The hair color varies from white to black, and the pigment granules vary accordingly from none to many.

Among the *Mustelidae* the cuticular scales of the fur hairs are highly modified in some genera. Among the *Canidae* the scales of the protective hairs are the bearers of helpful characteristics. In general though the scales are rather simple. A medulla is always present, at least in the widest portion of the hair and is continuous in the protective hairs and may be continuous or interrupted in the fur hairs. The medulla seldom constitutes less than 40 per cent of the shaft

Genus	Protective hair									
	Diameter at widest part in microns			Proportional diameter of medulla at widest part of shaft			Scale index			
							Base		Wide part	
	Min.	Mean	Max.	Min.	Mean	Max.	Index	Diam. microns	Index	Diam. microns
Euarctos	104	**138**	190	0.18	**0.34**	0.42	0.33	110	0.10	170
Ursus	100	**163**	260	0.09	**0.27**	0.40	0.16	176	0.10	248
Thalarctos	80	**139**	200	0.19	**0.37**	0.50	0.16	50	0.11	160 widest
									0.35	128 mid-section
Procyon	100	**161**	268	0.19	**0.38**	0.53	0.28	120	0.09	228
Bassariscus	95	**170**	150	0.60	**0.77**	0.84	0.78	64	0.16?	100
Martes	72	**136**	176	0.60	**0.67**	0.79	1.11	72	0.10	150
Mustela	92	**149**	176	0.56	**0.80**	0.87	1.60	48	0.12	140
							0.84	60	0.07	168
Gulo	160	**204**	264	0.41	**0.52**	0.64	0.12	96	0.08	176
							0.40	96		
Lutra	235	**280**	330	0.34	**0.53**	0.60	0.16	80	0.12	304
							0.43	104		
Enhydra	64	**120**	208	0.15	**0.20**	0.22	0.88	92	0.06	200
Spilogale	40	**111**	204	0.31	**0.62**	0.79	2.4	24	0.12	84
Mephitis	48	**150**	248	0.32	**0.52**	0.80	0.21	74	0.06	172
							0.14	104		
Conepatus	84	**189**	300	0.34	**0.53**	0.66	0.15	92	0.06	180
							0.14	120		
Taxidea	160	**222**	300	0.52	**0.75**	0.91	0.16	120	0.09	264
							0.30			
Vulpes	108	**153**	220	0.60	**0.74**	0.84	0.28	116	0.10	152
Urocyon	140	**189**	268	0.63	**0.74**	0.80	0.46	152	0.10	228
Alopex	56	**85**	132	0.33	**0.61**	0.76	0.78	52	0.32	88
Canis	156	**191**	228	0.55	**0.69**	0.88	0.16	192	0.10	180
							0.21	160		
Felis	132	**167**	208	0.47	**0.62**	0.70	0.14	84	0.07	172
							0.42			
Lynx	88	**152**	184	0.67	**0.75**	0.83	0.14	88	0.04	176

Genus	Fur hair									
	Diameter at widest part in microns			Proportional diameter of medulla at widest part of shaft			Scale index		Cortical pigment	Medullar pigment
	Min.	Mean	Max.	Min.	Mean	Max.	Index	Diam. in microns		
Euarctos	50	**61**	76	0.31	**0.36**	0.50	1.00	40	√	√
Ursus	44	**77**	108	0.12	**0.20**	0.27	0.50	64	√	ab.
Thalarctos	44	**69**	120	0.25	**0.36**	0.50	0.80	80	ab.	ab.
				0.00						
Procyon	20	**32**	60	0.33	**0.41**	0.67	2.40	20	√	ab.
				0.00			1.60	32		
Bassariscus	20	**24**	30	0.37	**0.55**	0.67	1.80	20	ab.	√
							0.53	28		
Martes	20	**28**	36	0.43	**0.56**	0.67	5.00	20	varies	?
							1.70	30		
Mustela	15	**22**	30	0.50	**0.66**	0.75	3.20	18	√	ab.?
							0.41	28		
Gulo	40	**50**	76	0.32	**0.45**	0.54	1.30	35	varies	√
							0.46	64		
Lutra	12	**16**	24	0.00	**0.16**	—	6.00	12	ab.	ab.
							4.00	16		
Enhydra	20	**31**	56	0.00	**0.20**	(0.60)	4.00	20	√	ab.
							1.80	36		
Spilogale	16	**26**	56	0.33	**0.41**	0.67	1.76	12	ab.	ab.
							0.95	28		
Mephitis	24	**37**	64	0.14	**0.30**	0.50	0.66	32	√	ab.
							0.40	56		
Conepatus	28	**46**	80	0.00	**0.21**	0.25	0.51	28	√	√
							0.19	60		
Taxidea	36	**48**	60	0.27	**0.30**	0.47	0.75	48	ab.	√
Vulpes	20	**26**	40	0.60	**0.70**	0.80	1.00	24	ab.	ab.
Urocyon	24	**30**	40	0.37	**0.53**	0.62	1.40	28	ab.	ab.
							0.70	36		
Alopex	20	**30**	60	0.40	**0.57**	0.69	1.60	20	ab.	?
							1.00	36		
Canis	28	**55**	100	0.28	**0.48**	0.65	1.25	36	ab.	√
							0.15	96		
Felis	28	**58**	112	0.25	**0.42**	0.47	1.30	32	√	√
							0.28	48		
Lynx	16	**27**	40	0.37	**0.55**	0.70	1.05	20	rare	√
							0.67	24		

diameter except in the *Ursidae*. It is often as much as 75 per cent of that measurement at the widest part of the shaft. The medullary cells vary considerably in size and shape and constitute a good character for some genera. In general there is not a great deal of pigment between the cells of the medulla.

Although it is possible to recognize some of the genera from either a protective or a fur hair several of both are usually required for positive determination.

The following tabulations of gross characteristics that are easily observed and measured may be of assistance in pointing the way to a determination. In no case do these figures apply to single hairs. A satisfactory average figure can be made from measurements of as few as twenty individual hairs. The examiner must use his own judgement about the validity of any series of measurements he makes on this basis.

A Key to the Protective Hair of the *Carnivora*

Medulla less than 0.4 of diameter of the shaft at its widest part.....1
Medulla between 0.4 and 0.7 of the diameter of the shaft at its widest part.....2
Medulla over 0.7 of the diameter of the shaft at its widest part.....3

Section 1

a. Medulla of clearly defined cells (see Fig. 18).....b
Medulla of ill-defined cells.....*Procyon*

b. Cortex free of pigment.....*Thalarctos*
Cortex pigmented.....c
c. Medulla fragmentary in basal region.....*Ursus* *
Medulla usually interrupted in the basal region.....
.....*Euarctos* *

Section 2

a. Maximum diameter of the shaft less than 100μ.....b
Maximum diameter of the shaft between 100μ and 200μ.....d
Maximum diameter of the shaft greater than 200μ...i
b. Cortex free of pigment.....*Alopex* (white phase)
Cortex pigmented.....c
c. Medulla fragmentary.....*Enhydra*
Medulla interrupted or continuous.....*Spilogale*
d. Medulla principally fragmentary.....*Enhydra*
Medulla otherwise.....e
e. Extreme basal portion of this fragmentary.....g
Extreme basal portion of this interrupted.....f
f. Medullary cells at base of hair uniform and globose (see fig. 76).....*Spilogale*
Medullary cells at base of hair irregular in size and shape (see Fig. 45).....*Martes*
g. Basal portion of medulla tapers abruptly.....*Canis*
Basal portion of medulla tapers gradually.....h
†*h.* Hair is tawny or white and does not show any considerable increase in diameter beyond the mid point.....*Felis*
Hair is black or white and usually shows some increase in diameter beyond the mid point.....
.....*Conepatus* or *Mephitis*
i. Distal portion of the shaft markedly spatulate...*Lutra*
Not so.....j
j. Extreme basal portion of the medulla is fragmentary.k
This not fragmentary.....*Lutra*
k. Extreme basal portion of medulla tapers abruptly.*Canis*
Not so.....l
l. Medullary cells flattened (see Fig. 91).....*Conepatus*
Medullary cells globular (see Fig. 57).....*Gulo*

Section 3

a. Maximum diameter of shaft over 200μ.....b
Maximum diameter of shaft under 200μ.....d
b. Scales elongate at least over most of basal half of shaft.....c
Scales irregular but not elongate.....*Taxidea*
c. Scale index in mid-part of shaft over 0.3.....*Urocyon*
Scale index in mid-part of shaft less than 0.2.....*Canis*
d. Medulla contains many large strongly inflated cells in the region of maximum diameter.....*Lynx*
Such cells absent or very rare.....e
e. Distal portion of the shaft markedly swollen.....f
Distal portion of the shaft not so.....g
f. Medullary cells at the base robust, flattened, often joined together as in a horizontal "H" or "U".....*Martes*
Medulla at the base without distinct cells but deeply indented giving the impression of flattened cells.....*Mustela*

g. Basal portion of medulla interrupted.....*Bassariscus*
Basal portion of medulla fragmental.....i
h. Scale index at mid-part of the shaft greater than 0.3.....*Urocyon*
Scale index at mid-part of the shaft less than 0.2....i
i. Seldom more than two "courses" of cells across the medulla at the maximum diameter.....*Vulpes*
Usually more than four "courses" of cells across the medulla at the maximum diameter.....*Canis*

A KEY TO THE FUR HAIR OF THE *Carnivora*

1. Shaft diameter greater than 40μ.....2
Shaft diameter less than 40μ.....16
2. Pigment and stain present in mid-part of shaft.....3
Pigment and stain absent in mid-part of shaft.....9
3. Medulla greater than 0.3 of shaft diameter.....5
Medulla less than 0.3 of shaft diameter.....4
4. Medulla absent.....*Procyon*
Medulla present.....7
5. Medulla interrupted.....6
Medulla fragmental.....*Procyon*
6. Scales elongate, no medullary pigment.....*Euarctos*
Scales usually not elongate, medullary pigment...*Felis*
7. Medulla interrupted.....*Felis*
Medulla fragmentary.....8
8. Scale index in basal half less than 0.5.....*Conepatus*
Scale index in basal half greater than 0.5.....*Ursus*
9. Medulla interrupted.....10
Medulla not interrupted type.....11
10. Scales strongly elongate.....*Gulo*
Scales flattened.....12
11. Medulla absent or highly fragmental.....*Taxidea*
Medulla continuous.....*Mephitis*
12. Cells of medulla separated by pigment masses..*Canis*
Cells of medulla not separated by pigment masses...13
13. Distal portion of hair with cortical pigment...*Mephitis*
Distal portion of hair without cortical pigment.....14
14. Cells globular.....*Spilogale*
Cells flattened.....15
15. Scale index at diam. 50μ about 0.5.....*Thalarctos*
Scale index at diam. 50μ about 1.0.....*Alopex*
16. Pigment present.....17
Pigment absent.....22
17. Medulla less than 0.3 of the shaft diameter.....18
Medulla greater than 0.3 of the shaft diameter.....19
18. Medulla fragmentary.....*Conepatus*
Medulla interrupted.....*Felis*
19. Medulla fragmentary, often highly so.....*Procyon*
Medulla interrupted.....20
20. Cells separated by pigment masses.....21
Cells not separated by pigment masses.....*Mustela*
21. Cortex lightly stained, yellowish.....*Felis*
Cortex not stained.....*Lynx*
22. Medulla less than 0.3 of the shaft diameter.....23
Medulla more than 0.3 of the shaft diameter.....26
23. Scales with broad distal tine (see Fig. 65).....*Lutra*
Scales not markedly elongate.....24
24. Medulla interrupted, pigment masses between cells...
.....*Canis*
Medulla lacking pigment masses.....25
25. Medulla usually fragmental, scale index less than 0.7, pigment often present near tip.....*Mephitis*
Medulla usually interrupted, scale index greater than 0.7.....*Taxidea*
26. Pigment masses between medullary cells.....27
Pigment masses not present.....30

* *Note.*—These may be readily separated by means of the fur hair (see Figs. 20 and 28).

† *Note.*—This bracket breaks down badly. Consult the figures and text. The fur hairs of these three genera separate easily.

27. Scales strongly elongate, at least basal ones with distal tine ..... *Martes*
    Not so 28
28. Scale index at 30μ diameter under 1.00 29
    Scale index at 30μ diameter over 1.00 ..... *Canis*
29. Medullary cells widely spaced ..... *Bassariscus*
    Medullary cells rather close together ..... *Lynx*
30. Medulla interrupted 31
    Medulla fragmental, occasionally partly interrupted ..... *Mephitis*
31. Scales flattened ..... *Spilogale*
    Scales elongate, at least slightly so 32
32. Scale index at 25μ over 1.00 33
    Scale index at 25μ less than or just 1.00 ..... *Vulpes*
33. Scale index at 35μ less than 0.9 ..... *Urocyon*
    Scale index at 35μ more than 0.9 ..... *Alopex*

As I have said in the introductory pages, these keys are not too trustworthy. The differences between the genera are real but in many instances defy generalization because so variable.

URSIDAE

The Bears

The protective hairs are long and usually between 100 and 200 micra in diameter at the widest part. The medulla rarely composes as much as 50 per cent of the shaft diameter, usually it is less than 40 per cent.

The fur hair is thick, coarse and kinky. The diameter ranges up to about 80 microns. The medulla is usually interrupted. There is a very scant deposit of medullary pigment in both *Euarctos* and *Ursus* and none in *Thalarctos*.

Key to the Genera of *Ursidae*

Protective Hair

1 *a*. Medullary pigment absent ..... *Thalarctos*
  b. Medullary pigment present 2
2 *a*. Average medulla less than 30 per cent of the shaft diameter ..... *Ursus*
  b. Average medulla greater than 30 per cent of the shaft diameter ..... *Euarctos*

Fur Hair

1 *a*. Medullary pigment absent ..... *Thalarctos*
  b. Medullary pigment present 2
2 *a*. Medulla "beaded," continuous ..... *Euarctos*
  b. Medulla usually absent or fragmental ..... *Ursus*

Euarctos[7]

The Black Bears

The hairs from the bears of this genus may be readily separated from those of *Ursus* upon the proportionate diameter of the medulla of the protective hair.

Protective Hair

Color: white (rare): yellowish through the browns to black.
Length: seldom exceeding 5 cm.
Diameter: 104μ–190μ; mean 138μ.
Scale Indices: basal 0.33 (110μ), 0.40 (120μ); mid-shaft 0.10 (170μ).
Cortex: stained and pigmented; reddish brown granules.
Medulla: *index:* 0.34 (0.186–0.425).
Form: continuous; thin plinths to almost globular cells.
Pigment: sparse, intercellular.

Fur Hair

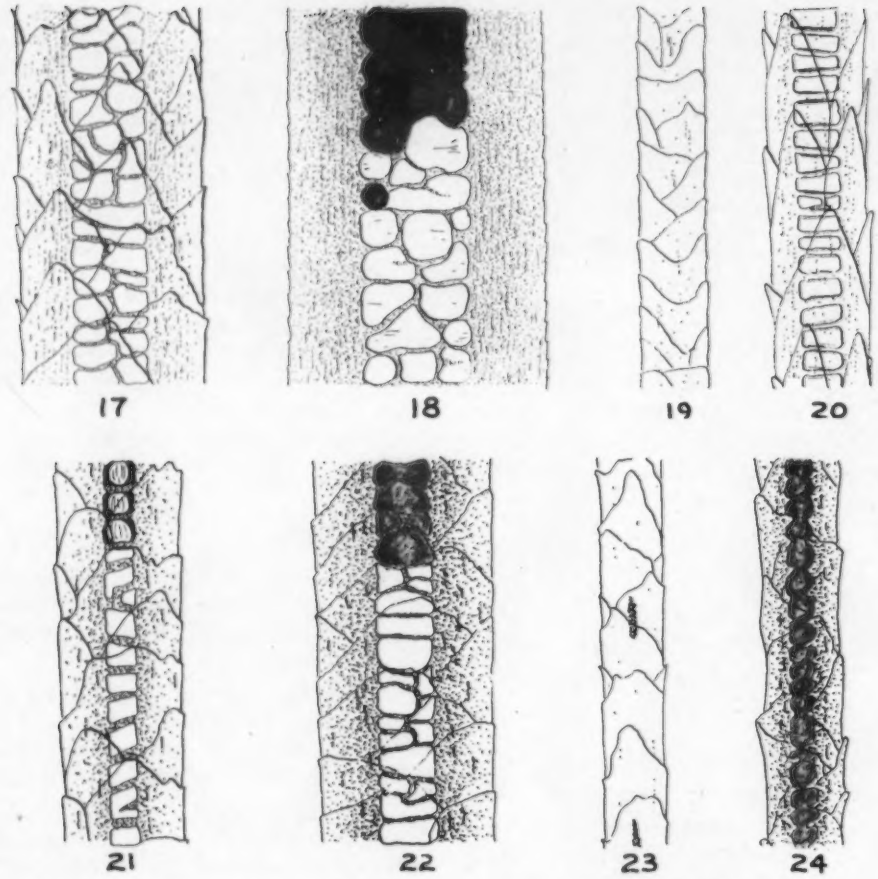
Color: white to dark brown.
Length: 2 to 3 cm; kinky.
Diameter: 50μ–76μ; mean 61μ.
Scales: usually prominent; index usually over 1.00, free margin fairly smooth and distally prolonged.
Cortex: usually lightly stained and pigmented; unstained hairs do occur.
Medulla: *index:* 0.36 (0.31–0.50).
Form: interrupted, extreme basal usually fragmental; cells globular or cylindrical plinths.
Pigment: sparse; intercellular.

Important Characteristics

The structure of the medulla of the fur hair and the proportionate diameter of the medulla in the protective hairs are characteristics which serve to separate the bears of this genus from *Ursus*. The protective hair may be distinguished from the coarse hair from the back of the beaver, with which it might be confused under some conditions, by the very much greater scale index of the bear hair and the arrangement of the pigment granules in the cortex. The color and medullary proportion of the protective hair may lead to confusion of *Euarctos* with *Enhydra* from which separation is easy because of the peculiar abrupt distal swelling of the hair shaft in the latter genus.

[7] In order to reduce the original manuscript to a more compact and more easily used form the descriptions of the hair as found in the various genera have been condensed to a mere outline of important characters. A uniform series of characters has been used to make comparison more simple and clear. Certain of these must be explained in their abbreviated form. The *Diameter* given is that of the widest portion of the hair shaft as measured by means of an ocular micrometer. The *Scale indices* are accompanied by the diameter for the particular specimen noted. This figure is in parentheses. The *index* for the *Medulla* is the proportion of the shaft occupied by that structure at the widest part of the shaft.

The range and other specific data may be readily found in H. E. Anthony—*A Field-book of Mammals*, Putnam Co.



FIGS. 17 TO 24. *Euarctos americanus* (Pallas) CMNH 178.

FIG. 17	protective	basal	120μ	FIG. 21	protective	basal	76μ
FIG. 18	protective	distad	168μ	FIG. 22	protective	mid	112μ
FIG. 19	fur	basal	40μ	FIG. 23	fur	basal	40μ
FIG. 20	fur	mid	64μ	FIG. 24	fur	mid	60μ

URSUS

The Grizzly (and Big Brown Bears?)

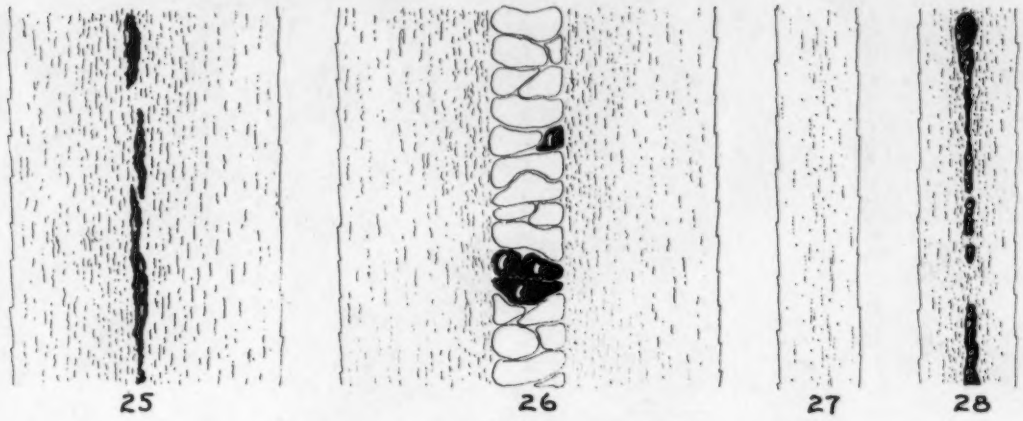
The grizzly bears may be recognized immediately by the very slender medullary column. I have not had the opportunity to study the Big Brown Bears as yet but suspect that they too will show this characteristic.

PROTECTIVE HAIR

COLOR: usually rich brown; rarely whitish or black; frequently tipped with whitish in some species or races.
LENGTH: usually 6 to 8 cm rarely over 10 cm.
DIAMETER: 100μ–260μ; mean 163μ.
SCALE INDICES: basal 0.16 (176μ); widest part 0.10 (248μ).
CORTEX: usually deeply stained and lightly pigmented; color primarily due to stain.
MEDULLA: *index:* 0.27 (0.09–0.40).
Form: base—absent to fragmental. Midshaft—continuous, cells robust and of various rounded forms.
Pigment: rare; intercellular.

FUR HAIR

COLOR: dingy to blackish brown.
LENGTH: about 3 cm, curly.
DIAMETER: 44μ–108μ; mean 77μ.
SCALES: not very prominent; smoothly margined; *index:* 0.70 at the base to 0.50 in midsection.
CORTEX: lightly stained and pigmented; color seems to be primarily due to pigment.



FIGS. 25 TO 28. *Ursus horribilis* Ord. CMZS.

FIG. 25 . . . . . protective . . . basal 176μ
FIG. 26 . . . . . protective . . . mid 248μ
FIG. 27 . . . . . fur . . . . . base 52μ
FIG. 28 . . . . . fur . . . . . mid 64μ

MEDULLA: *index:* 0.20 (0.12–0.27); absent in about 40 per cent of hairs examined.
Form: fragmental 90 per cent; continuous 10 per cent.
Pigment: absent.

IMPORTANT CHARACTERISTICS

The proportional diameter of the medulla plus uniformly great diameter seems to be diagnostic for *Ursus*.

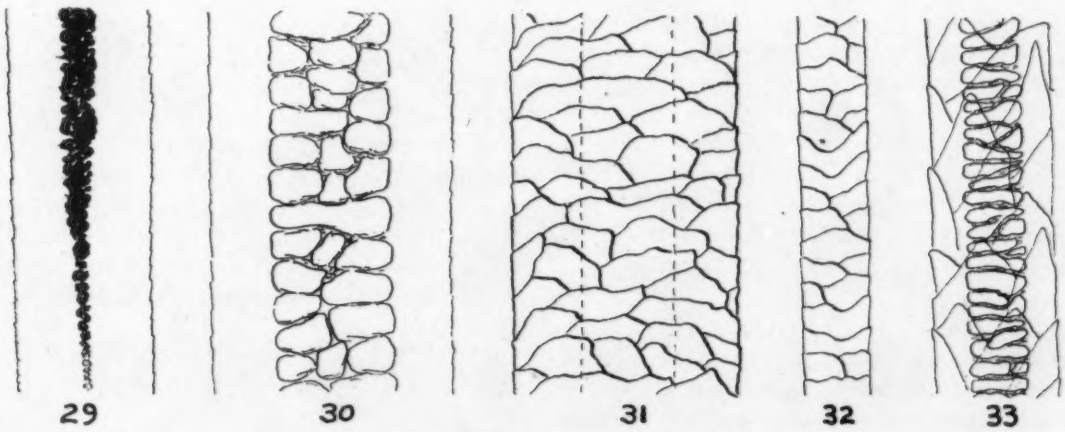
THALARCTOS

Polar Bears

Nine out of ten times the hairs of these bears are easily identified. The total lack of pigmentation makes this so. The tenth time the confusion is that which might be brought about by the rare white hairs of the Kermode Bear (*Euarctos kermodei* (Horniday)). White hairs from either *Ursus* or *Euarctos* usually have a scattering of very pale reddish brown pigment granules between the medullary cells.

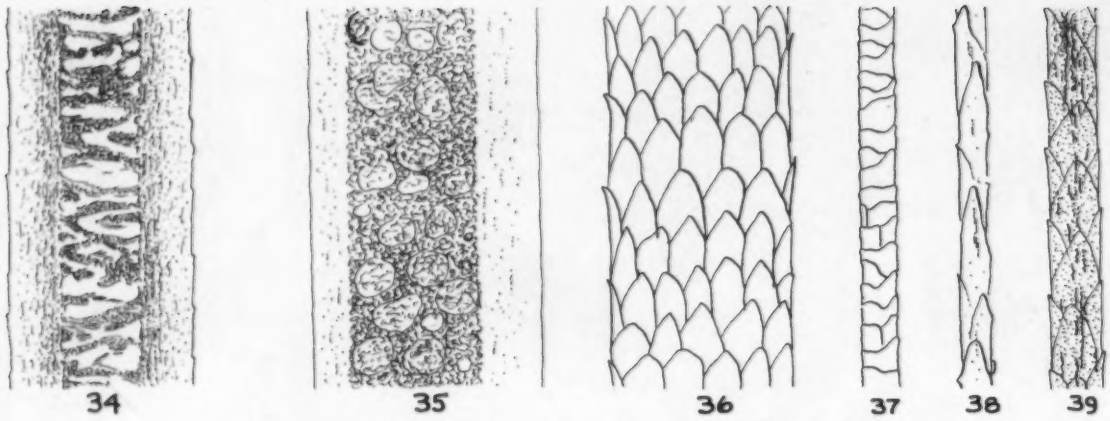
PROTECTIVE HAIR

COLOR: white to yellowish.
LENGTH: usually not more than 3 cm.
DIAMETER: 80μ–200μ; mean 139μ.
SCALE INDICES: basal 0.16 (50μ); mid-shaft 0.35 (128μ); widest region 0.11 (160μ).
CORTEX: rarely stained yellowish; no pigment; frequent fusi.



FIGS. 29 TO 33. *Thalarctos maritimus* (Phipps) CMNH 2708.

FIG. 29 . . . . . protective . . . base 52μ
FIG. 30 . . . . . protective . . . mid 160μ
FIG. 31 . . . . . protective . . . mid 148μ
FIG. 32 . . . . . fur . . . . . base 44μ
FIG. 33 . . . . . fur . . . . . mid 80μ



FIGS. 34 TO 39. *Procyon lotor lotor* (Linnaeus) CMNH 1855.

FIG. 34	protective	basal	120μ	FIG. 37	fur	base	24μ
FIG. 35	protective	mid	152μ	FIG. 38	fur	basal	20μ
FIG. 36	protective	basal	120μ	FIG. 39	fur	mid	34μ

MEDULLA: *index:* 0.37 (0.19–0.50).
Form: continuous; flattened globular cells rather uniform in size.
Pigment: absent.

FUR HAIR

COLOR: white.
LENGTH: about 2 cm; kinky.
DIAMETER: 44μ–120μ; mean 69μ.
SCALES: fairly prominent; *indices:* basal 0.40 (44μ), mid-shaft 0.80 (80μ).
CORTEX: free of stain and pigment.
MEDULLA: *index:* 0.36 (0.25–0.50).
Form: continuous, the cells are thin plinths.
Pigment: absent.

IMPORTANT CHARACTERISTICS

The freedom from pigmentation and the relatively narrow medullary column should at once identify the hairs of *Thalarctos*.

PROCYONIDAE

PROCYON

Racoons

PROTECTIVE HAIR

COLOR: grey, brown, black and grizzled; white rare.
LENGTH: usually about 4 cm, occasionally to 6 cm.
DIAMETER: 100μ–268μ; mean 161μ.
SCALES: elongate, smooth margined, moderately prominent at the base; *indices:* basal 0.30 (120μ), 0.10 (228μ).
CORTEX: stained golden brown in pigmented areas; granules crowded toward medulla.
MEDULLA: *index:* 0.38 (0.19–0.53).
Form: continuous, cells variable in size and shape; impression is that medulla is a froth with various sized bubbles.
Pigment: considerable; intercellular.

FUR HAIR

COLOR: grey-white to deep brown.
LENGTH: 2–3 cm, kinky.
DIAMETER: 20μ–60μ; mean 32μ.
SCALES: prominent: basal region flat elsewhere elongate. *Indices:* basal 0.50 (30μ); elsewhere 2.4 (20μ), 1.6 (32μ).
CORTEX: usually stained rich warm brown, stainless not rare; pigment granules well distributed, base usually free of pigment and stain.
MEDULLA: usually absent (90 per cent): highly fragmental in 10 per cent; in these the index averages 0.41 (0.33–0.67). *Pigment:* absent.

IMPORTANT CHARACTERISTICS

The medullary structure of the protective hairs is rather diagnostic *when considered for the whole length of the specimen.* This, plus non-medullated, well-pigmented fur hair with elongated scales should be considered almost positive.

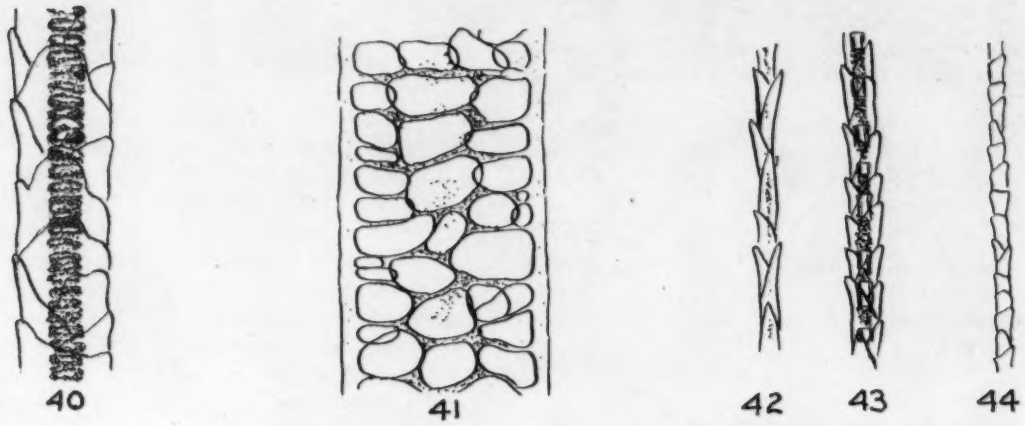
BASSARISCIDAE

BASSARISCUS

Ring-tailed Cats

PROTECTIVE HAIR

COLOR: white, buff, grey and blackish brown; the darker hairs grizzled.



FIGS. 40 TO 44. *Bassariscus astutus flavus* (Rhoads) CMNH 1990.

FIG. 40.....protective...basal.....60μ
FIG. 41.....protective...mid.....136μ
FIG. 42.....fur.....base.....12μ
FIG. 43.....fur.....mid.....20μ
FIG. 44.....fur.....tip.....10μ

LENGTH: usually less than 2 cm, rarely over 3 cm.
DIAMETER: 95μ–150μ; mean 107μ. Back hairs consistently coarser than flank or belly hairs.
SCALES: smoothly rounded, prominent at base; *indices:* basal, 0.8 (64μ); widest part, 0.16? (100μ).
CORTEX: faintly stained yellow-brown in dark areas; dark brown pigment granules.
MEDULLA: *index:* 0.77 (0.60–0.84).
Form: continuous, semi-globular cells.
Pigment: abundant, intercellular, light reddish brown granules.

FUR HAIR

COLOR: white or greyish.
LENGTH: about 1.5 cm, rarely 2 cm.
DIAMETER: 20μ–30μ; mean 23.6μ.
SCALES: prominent; basal and those in narrow parts of shaft strongly produced, smooth-edged and flaring, in widest parts apressed and not produced distally. *Index:* 1.8 (20μ) to 0.53 (28μ).
CORTEX: free of stain and pigment.
MEDULLA: *index:* 0.55 (0.37–0.67).
Form: fragmental at base, elsèwhere interrupted, cells widely spaced cylindrical plinths.
Pigment: small clusters of faintly colored granules attached to basal surface of the cells.

IMPORTANT CHARACTERISTICS

The shape of the medullary cells in the basal portion of the protective hair plus the characteristic of the diameter and large proportion of medulla will help to set this genus apart from those with which it may be confused. The diameter, scale form, and medullary pigment, when taken together, will identify the fur hair.

MUSTELIDAE

WEASELS, SKUNKS, BADGERS, etc.

Nine genera of the *Mustelidae* are found in North America. These are divided among six sub-families. I have been unable to detect any character or combination of characters that will set this family apart from other *Carnivora*. Many of the members are important fur-bearers today and doubtlessly were to the aborigines as well. I have seen strands of wool made from *Lutra* fur and have seen many pieces of clothing and adornment incorporating the furry hides of these animals. A beautiful Blackfoot headdress (FBI-45-P, Denver Art Museum Coll.) is made almost wholly of the tails of *Mustela longicauda*. A Nez Perce shirt belonging to William Berger, Jr. in Denver is trimmed with fur from *Enhydra*.

MUSTELINAE

MARTENS, WEASELS AND MINK

Martes and *Mustela* represent this sub-family in the territory covered by this paper. Relatively short carnivore hairs (under 3 cm) with the medulla composing over 50 per cent of the shaft in the basal region and made up of flattened cells extending across the full column may with fair reliability be assigned to this sub-family.

KEY TO THE PROTECTIVE HAIRS

1 *a.* Medullary cells at the base robust, flattened, often two joined together as in horizontal "U" or "H"..... *Martes*

b. Medulla at the base without distinct cells but deeply indented giving the impression of flattened cells..... *Mustela*

KEY TO FUR HAIRS

1 *a.* Cuticular scales at the base with a long slender tine pointing distad..... *Martes*

b. Cuticular scales lacking these tines..... *Mustela*

MARTES

Martens and Fishers

PROTECTIVE HAIR

COLOR: from white to black; usually some shade of brown.

LENGTH: from 2.5 to 4 cm, occasionally 5 cm.

DIAMETER: 72μ–176μ; mean 136μ.

SCALES: prominent in basal portion, acuminate; rather inconspicuous elsewhere; *index:* 1.1 (72μ) basal; 0.10 (150μ).

CORTEX: lightly stained; very small, rich brown granules abundant.

MEDULLA: *index:* 0.67 (0.60–0.79).

Form: continuous; cells robust, some joined in simple shapes as horizontal "U's" and "H's" in basal area.

Pigment: fine, intercellular granules.

FUR HAIR

COLOR: pale greyish brown to white.

LENGTH: about 2 cm.

DIAMETER: 20μ–36μ; mean 28μ.

SCALES: the cuticular scales at the base are interesting in that they bear a long slender digitate tine on the distal margin. This is almost equal to the free proximo-distal dimension in length. A similar process is found in *Lutra*. In that genus the base of the process is tapered; in this the tine is an abrupt projection from the free margin. The scales of the body of the hair are acuminate and in that way differ from the scales in the same region of the fur hair of *Lutra* where they are similar to those of the base but broadened. The scales at the tip are simple and flattened. *Index:* basal about 5.0 (diam. 20μ); wider parts 1.7 (diam. 30μ).

CORTEX: occasionally lightly stained.

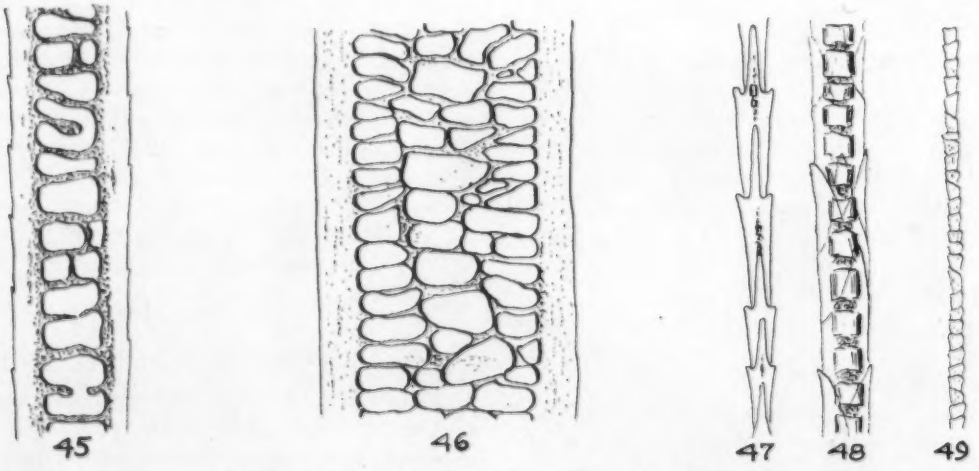
MEDULLA: *index:* 0.56 (0.43–0.67).

Form: interrupted.

Pigment: doubtfully present between the cells.

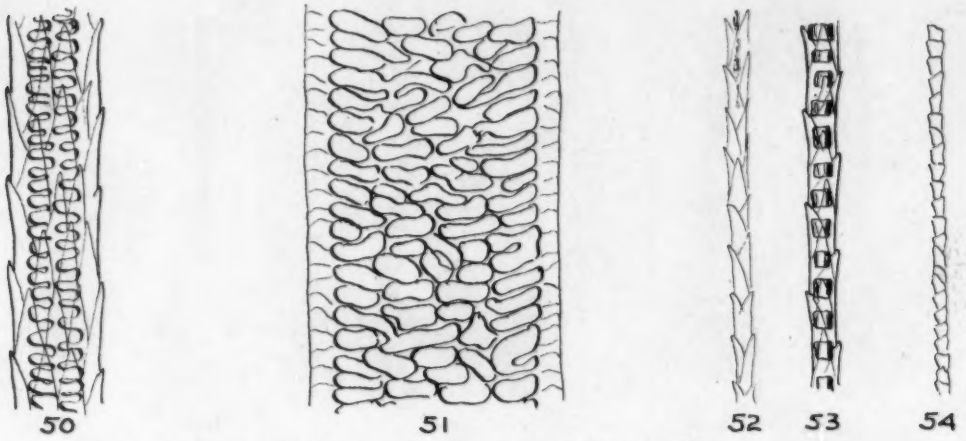
IMPORTANT CHARACTERISTICS

The form of the medulla plus the acuminate scales at the base is a fairly reliable combination of characteristics for the protective hairs. The cuticular scales and their variation in shape is a reliable basis for the identification of the fur hair.



FIGS. 45 TO 49. *Martes caurina* (Merriam) CMNH 48.

FIG. 45.....protective...basal.....78μ FIG. 47.....fur.....base.....14μ
FIG. 46.....protective...distal.....172μ FIG. 48.....fur.....mid.....32μ
FIG. 49.....fur.....tip.....8μ



FIGS. 50 TO 54. *Mustela arizonensis* (Mearns) CMNH 1557.

FIG. 50.....protective...basal.....60μ
FIG. 51.....protective...distal.....168μ
FIG. 52.....fur.....base.....12μ
FIG. 53.....fur.....mid.....22μ
FIG. 54.....fur.....tip.....8μ

MUSTELA

Weasels and Mink

PROTECTIVE HAIR

COLOR: white, yellowish, black and all varieties of brown.

LENGTH: seldom exceeding 2 cm for weasels, a little longer in mink.

DIAMETER: 92μ–176μ; mean 149μ. Hairs of the flank on the average show less distal swelling than do the hairs from the back. A five-fold increase in diameter is not uncommon.

SCALES: prominent in the basal region; basal acuminate, elsewhere flattened. *Index:* basal 1.60 (48μ), 0.84 (60μ); elsewhere 0.12 (140μ), 0.07 (168μ).

CORTEX: white—free of stain and pigment. Yellowish—stained with little pigment. Brown—stained and pigmented, granules small and scattered.

MEDULLA: *index:* 0.80 (0.56–0.87).
Form: continuous, characteristic at base, see figure 50.
Pigment: absent.

FUR HAIR

COLOR: pale to white.

LENGTH: about 1.5 cm.

DIAMETER: 15μ–30μ; mean 22μ.

SCALES: acuminate at base, flattened elsewhere.

CORTEX: as in protective hair but never so intensely.

MEDULLA: *index:* 0.66 (0.50–0.75).
Form: interrupted.
Pigment: absent.

IMPORTANT CHARACTERISTICS

The cells of the medulla of the protective hair present a reliable index to this genus. The fur hair is less easily recognized but the scale index and form taken with the diameter is fairly reliable.

GULONINAE

GULO

Wolverines

The wolverines are the largest of the weasel family. They are found over the northern part of the continent southward to the northernmost states of the United States and through the Rockies as far south as Colorado.

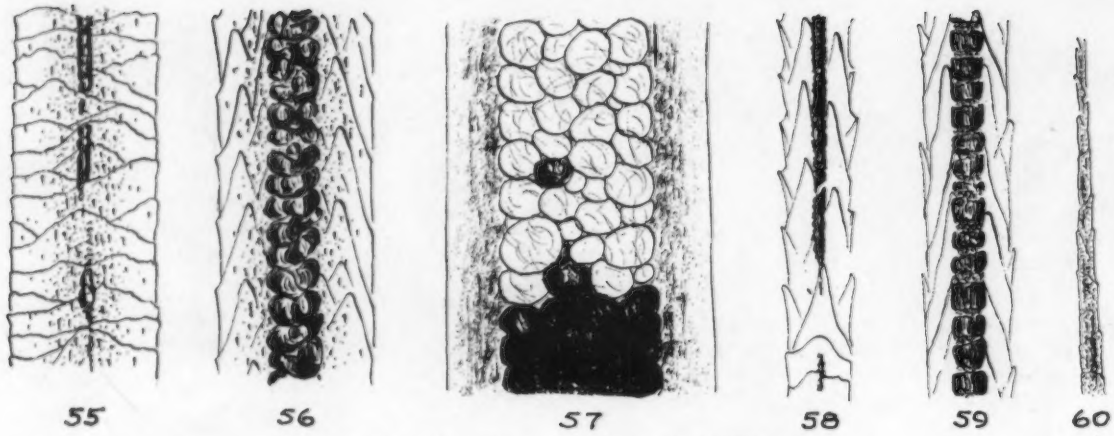
PROTECTIVE HAIR

COLOR: grizzled, light at base, yellowish to dark brown at tip.

LENGTH: up to 10 cm.

DIAMETER: 160μ–264μ; mean 204μ. Those of the back 160μ–192μ.

SCALES: the cuticular scales at the extreme base are flattened and the free margin is rough. As the medulla becomes continuous the scales elongate and become acuminate with smooth margins. As the full width of the hair is approached these scales again change form to a flattened, smooth-margined type. The scale index at the extreme base,



FIGS. 55 TO 60. *Gulo luscus* (Linnaeus) CMNH 1949.

FIG. 55	protective...basal	96μ	
FIG. 56	protective...basad	100μ	
FIG. 57	protective...mid	176μ	
FIG. 58	fur...base	40μ	
FIG. 59	fur...mid	56μ	
FIG. 60	fur...tip	8μ–16μ	

where the medulla is narrow and fragmentary, is 0.12 (diam. 96μ). In the region of acuminate scales it is 0.40 (diam. 96μ) and at the widest part of the hair 0.08 (diam. 176μ).

CORTEX: stain and pigment vary with color of hair; fusi prominent and appear like elongate pigment granules.

MEDULLA: *index:* 0.52 (0.41–0.64), from back 0.54–0.64.

Form: continuous, except for extreme base and tip, these fragmentary, cells globose.

Pigment: present?

FUR HAIR

COLOR: light.

LENGTH: 3 to 4 cm, kinky.

DIAMETER: 40μ–76μ; mean 50μ.

SCALES: acuminate except base and tip, then flattened; *index:* non-medullated base 0.39 (32μ), medullated base 1.30 (35μ), elsewhere 0.46 (64μ).

CORTEX: usually free of stain, pigment rare except in distal portion when it seems to be the rule.

MEDULLA: *index:* 0.45 (0.32–0.54).

Form: interrupted.

Pigment: scant, intercellular.

IMPORTANT CHARACTERISTICS

The globular cells of the medulla plus the gradual development of the medulla at the base and the changes in the form of the scales throughout the length of the hair shaft seem to characterize the protective hair of the wolverine. The fur hair may be recognized by its coarseness and the shape of the scales.

LUTRINAE

LUTRA

Otters

PROTECTIVE HAIR

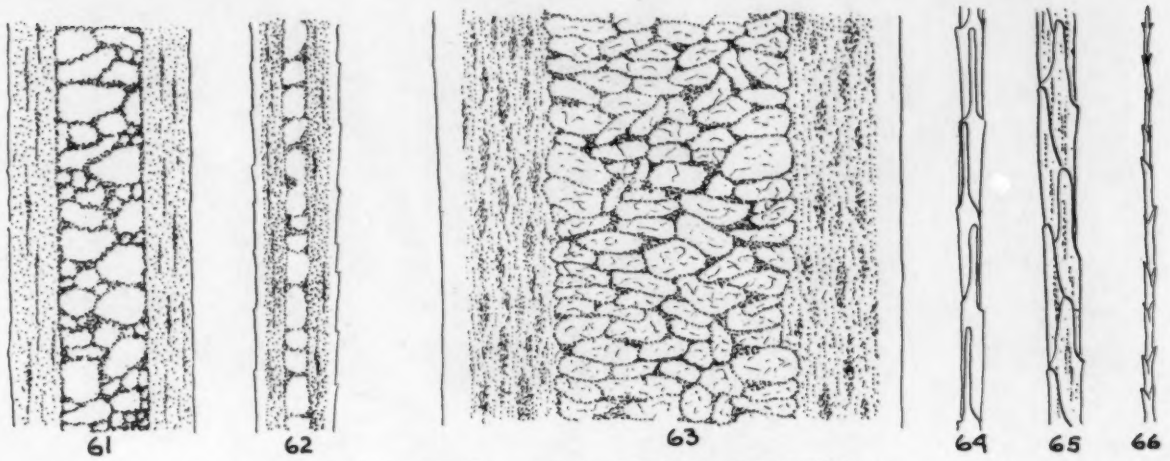
COLOR: shades of brown.

LENGTH: up to 3 cm, rarely 6 cm.

DIAMETER: 235μ–330μ; mean 280μ. The distal portion of the hairs is usually markedly wider than the proximal (Fig. 3). In some instances this increase may exceed by sixfold the narrowest portion of the hair. Most of the hairs have a curious reduction in the diameter about a quarter of the length of the hair from the base. This may amount to as much as 50 per cent and occurs in the short space of a hundred or so microns. The swollen portion of the shaft seldom occupies more than the distal third of the hair. It tapers abruptly to the tip.

SCALES: flattened at the base, acuminate through the distal two-thirds and flattened in the swollen portion. *Indices:* extreme base 0.16 (80μ), beginning of medulla 0.43 (104μ), just basad of constriction 0.83 (96μ), just distad of constriction 1.00 (64μ), widest part 0.12 (304μ).

CORTEX: stained yellowish brown and well filled with pigment granules. Throughout most of the densely colored parts of the



FIGS. 61 TO 66. *Lutra canadensis* (Schreber) CMNH 92.

FIG. 61	protective	base	120μ	FIG. 64	fur	base	20μ
FIG. 62	protective	basad	56μ	FIG. 65	fur	mid	24μ
FIG. 63	protective	distal	308μ	FIG. 66	fur	tip	6μ

shaft there is a narrow margin of cortical (possibly cutical) material free of stain and pigment.

MEDULLA: *index:* 0.53 (0.34–0.60).

Form: continuous, large cells with interstices filled with small ones.

Pigment: some intercellular granules.

FUR HAIR

COLOR: colorless, rarely brownish.

LENGTH: 1.0–1.5 cm, curly to kinky.

DIAMETER: 12μ–24μ; mean 16μ.

SCALES: the cuticular scales are widely spaced, having an index ranging between 4.0 and 6.0. They are distinctive in form, there being a long digitate tine on the free margin. This tine is very narrow in the basal portion of the hair and broader in the distal portion.

CORTEX: usually free of pigment and stain.

MEDULLA: usually absent: when present (5 per cent) highly fragmental and accompanied by light distal pigmentation of the cortex.

IMPORTANT CHARACTERISTICS

The peculiar shape of the longitudinal section of the protective hair is characteristic of *Lutra*. When this is absent the small flattened medullary cells and the full medullation of the extreme base will serve to indicate the genus. The fur hair may be recognized by the form of the scales. The considerable medulla in the protective hair and the general lack of pigment in the fur hair will serve to separate this genus from the following, *Enhydra*.

ENHYDRINAE

ENHYDRA

Sea Otters

PROTECTIVE HAIR

COLOR: dark brown, lighter toward the base.

LENGTH: 2–3 cm.

DIAMETER: 64μ–200μ; mean 120μ.

SCALES: smooth-margined, produced except in widest part of shaft, then flattened. *Indices:* base 0.88 (92μ), mid-region 0.24 (168μ), widest part 0.06 (200μ).

CORTEX: lightly stained, pigmentation in basal half light and in distal half very dense, granules small.

MEDULLA: *index:* impossible to measure due to density of cortical pigment in most hairs. Less than 0.20 in those measured.

Form: fragmentary to continuous, generally absent in flank hairs.

Pigment: probably absent.

FUR HAIR

COLOR: dingy brown, much lighter toward the base.

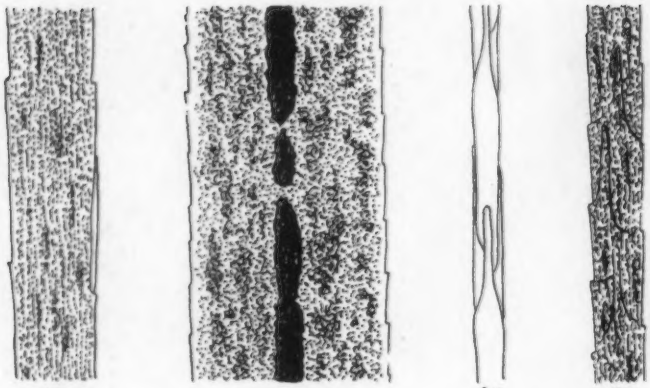
LENGTH: 1–1.5 cm.

DIAMETER: 20μ–56μ; mean 31μ.

SCALES: very much like those of *Lutra* q.v. *Indices:* 4.0 (20μ), 2.0 (24μ), 1.8 (36μ).

CORTEX: faintly stained, pigmentation variable, from densely packed dark brown to scattered pale brown granules.

MEDULLA: rarely present, then fragmentary 0.20–0.60.



FIGS. 67 TO 70. *Enhydra lutris* (Linnaeus) AMNH 75333.

FIG. 67 . . . . . protective . . . basal 58μ
FIG. 68 . . . . . protective . . . mid 128μ
FIG. 69 . . . . . fur . . . . . base 16μ
FIG. 70 . . . . . fur . . . . . mid 32μ

IMPORTANT CHARACTERISTICS

The very slender medullary column of the protective hairs may lead to confusion with Bears or Racoon. The typical abrupt swelling of the distal portion of the hair will serve to separate *Enhydra* from these. The swelling may confuse the hairs from this genus with those of *Lutra*. The hairs of *Enhydra* are easily separated by the very narrow medullary column they contain.

The fur hairs are difficult to separate with absolute certainty from those of *Lutra*. In general the fur hairs of *Lutra* lack pigment granules while those of *Enhydra* contain them.

MEPHITINAE

SKUNKS

The skunks are found over the entire North American continent from 50° N southward. They range farther north than this in the west. The family is well represented by three genera, *Spilogale*, *Mephitis*, and *Conepatus*. The genera are separable one from the others on the basis of hair structure but as yet I have been unable to find a set of characters that will isolate the family.

A KEY TO THE HAIR OF THE *Mephitinae*

Protective Hair

1 *a*. Medulla at the extreme base continuous, cells globular, in the mid-section continuous, cells flattened and often linked . . . . . *Spilogale*
b. Medulla at base fragmentary 2
2 *a*. Dark portion of the hair with a clear, hyaline margin; white hairs with the majority of the medullary cells flattened but not linked . . . . . *Conepatus*
b. Clear, hyaline margin rare in dark hairs; few of the cells in the medulla of white hairs flattened . . . . . *Mephitis*

Note.—Mephitis and *Conepatus* do not always separate according to the key for protective hairs.

Fur Hair

1 *a*. Medulla in central portion of the shaft interrupted . . . . . *Spilogale*
b. Medulla in the central portion of the shaft continuous or fragmentary 2
2 *a*. Medulla fragmentary . . . . . *Conepatus*
b. Medulla continuous or interrupted . . . . . *Mephitis*

Note.—Spilogale and *Mephitis* do not always separate according to the key for fur hairs.

Note.—Conepatus may always be recognized by its very low scale index.

SPILOGALE

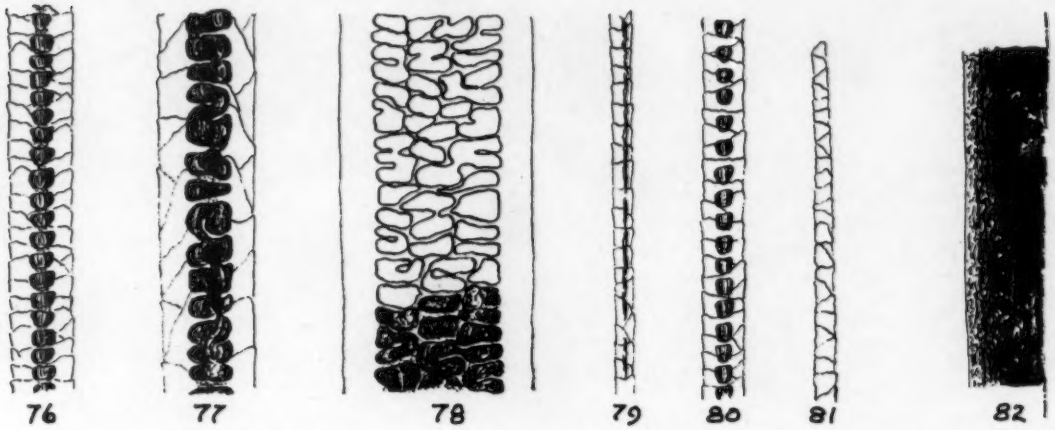
The Spotted Skunks

PROTECTIVE HAIR

COLOR: white—or black with whitish base.
LENGTH: up to 4 cm.
DIAMETER: 40μ–204μ; mean 111μ.
SCALES: flattened—crenate margins; *indices:* basal 2.4 (24μ), mid-region 0.35 (52μ), widest part 0.12 (84μ).
CORTEX: white—free of stain and pigment. Black—strongly stained, large dark granules.
MEDULLA: *index:* 0.62 (0.31–0.79).
Form: continuous, occasionally interrupted, cells at base globular and those in wide regions strongly flattened and often linked together into irregular flattened forms.
Pigment: sparse to absent.

FUR HAIR

COLOR: usually colorless.
LENGTH: under 2 cm.



FIGS. 76 TO 82. *Spilogale a. arizonae* (Mearns) ERW 3366.

FIG. 76 . . . . . protective . . . basal 40μ
FIG. 77 . . . . . protective . . . basad 60μ
FIG. 78 . . . . . protective . . . mid 124μ
FIG. 79 . . . . . fur . . . . . base 12μ
FIG. 80 . . . . . fur . . . . . mid 28μ
FIG. 81 . . . . . fur . . . . . tip 10μ
FIG. 82 . . . . . protective . . . mid . . . . pigmented

DIAMETER: 16μ–56μ; mean 26μ.
SCALES: smooth and flattened. *Indices:* basal 1.8 (12μ), mid-section 1.5 (20μ) and 0.95 (28μ).
CORTEX: usually free of pigment and stain.
MEDULLA: *index:* 0.41 (0.33–0.67).
Form: interrupted.
Pigment: absent.

IMPORTANT CHARACTERISTICS

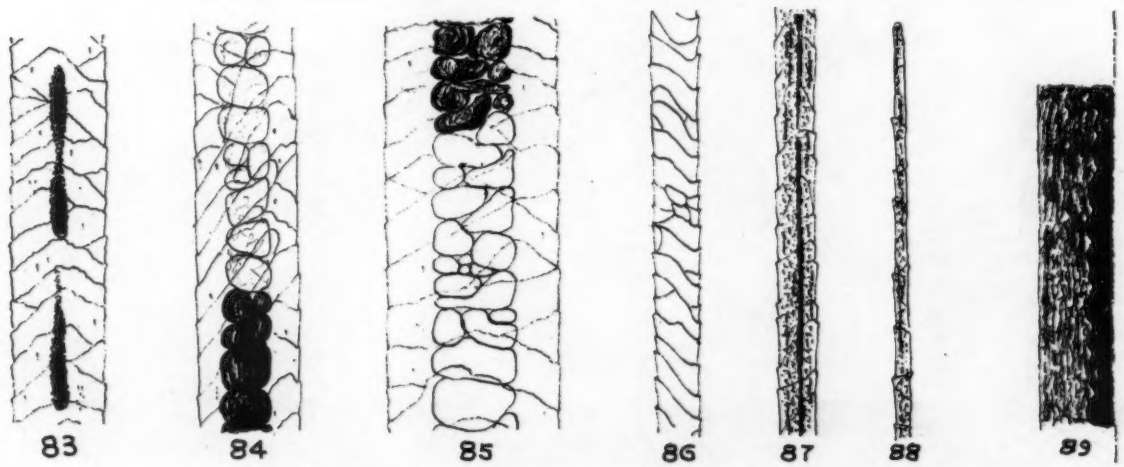
The arrangement and form of the cells in the mid-shaft medulla of the protective hairs and the interrupted medullary column of the fur hairs are good characteristics.

MEPHITIS

The Striped Skunks

PROTECTIVE HAIR

COLOR: same as *Spilogale* q.v.
LENGTH: up to 7 cm.
DIAMETER: 48μ–248μ; mean 150μ.
SCALES: flattened with crenate margin except at base when they are produced. *Indices:*



FIGS. 83 TO 89. *Mephitis hudsonica* (Richardson) ERW 1351.

FIG. 83 . . . . . protective . . . basal 60μ
FIG. 84 . . . . . protective . . . basad 64μ
FIG. 85 . . . . . protective . . . mid 112μ
FIG. 86 . . . . . fur . . . . . base 28μ
FIG. 87 . . . . . fur . . . . . distal 24μ
FIG. 88 . . . . . fur . . . . . tip 8μ
FIG. 89 . . . . . protective . . . mid . . . . pigmented

base 0.21 (74μ), medullate base 0.14 (104μ), mid-section 0.07 (176μ).

CORTEX: white—free of pigment and stain. Black: as in *Spilogale* but with smaller granules.

MEDULLA: *index:* 0.52 (0.32–0.80).
Form: continuous—more or less globular cells a few of which are compressed or distorted.
Pigment: absent.

FUR HAIR

COLOR: dusky.
LENGTH: 2–3 cm, wavy.
DIAMETER: 24μ–64μ; mean 37μ.
SCALES: smooth and flattened. *Indices:* at base 0.52 (32μ), medullated base 0.66 (32μ), widest part 0.40 (56μ), tip 1.25 (16μ).
CORTEX: usually free of stain except at tip, pigmentation most dense in wide parts of the hair.
MEDULLA: *index:* 0.30 (0.14–0.50).
Form: usually continuous, rarely pigmented or interrupted in the mid-section.
Pigment: absent.

IMPORTANT CHARACTERISTICS

The continuous nature of the medulla of the fur hair coupled with its diameter will serve to separate *Mephitis* and *Conepatus*. The medulla of the protective hair is constant in its difference from that of *Spilogale*. The clear cuticular region of *Conepatus* will separate the protective hair of that genus from this. The color of the hair is sufficient to differentiate *Mephitis* from *Felis*.

CONEPATUS

The Hog-nosed Skunks

PROTECTIVE HAIR

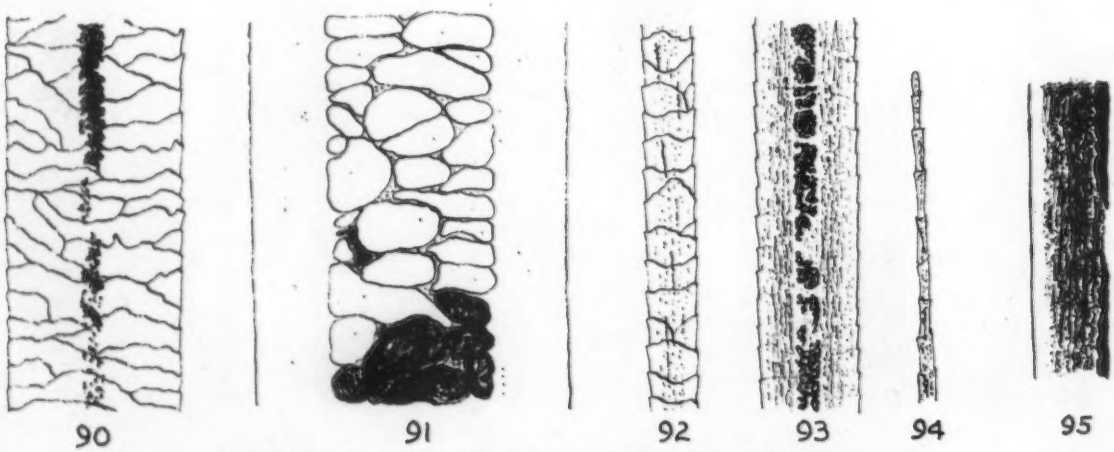
COLOR: dorsum, white; belly, dusky brown; flanks, black lighter at base.
LENGTH: 4–7 cm.
DIAMETER: 84μ–300μ; mean 189μ.
SCALES: flattened, crenate margin. *Indices:* basal 0.15 (92μ), widest part 0.06 (180μ).
CORTEX: about as in *Mephitis* q.v.
MEDULLA: *index:* 0.53 (0.34–0.66).
Form: continuous except at base, then fragmentary, cells flattened.
Pigment: intercellular, always present, even in white hairs.

FUR HAIR

COLOR: dusky to dark brown.
LENGTH: about 2.5 cm.
DIAMETER: 28μ–80μ; mean 46μ.
SCALES: flattened. *Indices:* from very fine hair, base 0.51 (28μ), wide portion 0.55 (40μ); from coarse hair 0.32 (48μ), 0.19 (60μ).
CORTEX: always pigmented and often stained lightly especially toward tip.
MEDULLA: *index:* 0.21 (0.00–0.25).
Form: absent or fragmentary.
Pigment: irregular intercellular masses.

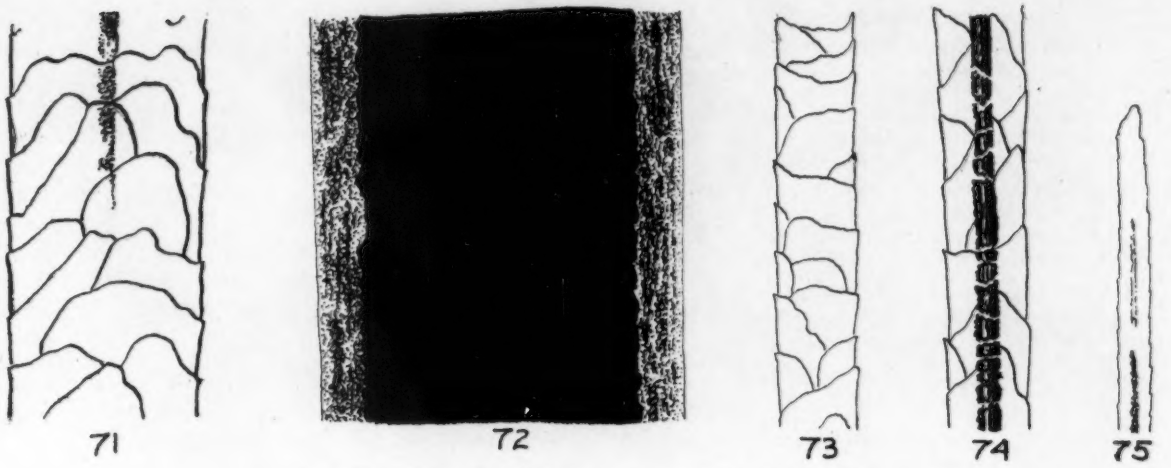
IMPORTANT CHARACTERISTICS

The large, irregular, flattened cells of the medulla of the protective hair plus the distinctly colorless cuticular zone will serve to identify this genus from those with which it might be confused. The medulla offers a good key to the fur hair.



FIGS. 90 TO 95. *Conepatus mesoleucas mearnsi* (Merriam) ERW 4252.

FIG. 90	protective	basal	108μ	FIG. 93	fur	mid	64μ
FIG. 91	protective	mid	208μ	FIG. 94	fur	tip	10μ
FIG. 92	fur	base	32μ	FIG. 95	protective	mid	pigmented



FIGS. 71 TO 75. *Taxidea taxus taxus* (Schreber) ERW 95.

FIG. 71.....protective...basal.....124μ
FIG. 72.....protective...mid.....240μ
FIG. 73.....fur.....base.....52μ
FIG. 74.....fur.....mid.....52μ
FIG. 75.....fur.....tip.....20μ

TAXIDIINAE

TAXIDEA

Badgers

PROTECTIVE HAIR

COLOR: grizzled, light at tip and base.
LENGTH: about 6–8 cm.
DIAMETER: 160μ–300μ; mean 222μ.
SCALES: irregular margins, prominent at the base. *Indices:* basal 0.16 (120μ), medullated base 0.30 (120μ), mid-section 0.28 (144μ), widest portion 0.09 (264μ).
CORTEX: free of stain in lightest parts, dark parts stained and filled with rather large ovoid reddish granules often gathered in flocculent groups.
MEDULLA: *index:* 0.75 (0.52–0.91); in basal region about 0.25 and gradually increasing to about 0.80.
Form: continuous, small compact cells.
Pigment: absent.?

FUR HAIR

COLOR: colorless or dingy grey.
LENGTH: 2–3 cm.
DIAMETER: 36μ–60μ; mean 48μ.
SCALES: prominent, slightly irregular margins.
CORTEX: free of pigment and stain.
MEDULLA: *index:* 0.30 (0.27–0.47).
Form: absent in the base, otherwise a continuous column of flattened globose cells.
Pigment: scattered pale intercellular granules.

IMPORTANT CHARACTERISTICS

The gross aspects of the hair combined with the scale form and the diameters of the medullary column throughout the shaft are safe characters for the identification of *Taxidea*.

CANIDAE

The four genera of the canines that are found in North America are grouped together in the sub-family *Caninae*. The scales of the protective hairs and the character of the medulla in the wide part of the shaft are fair characters for separating these mammals from the other carnivores found in the range covered by this paper. In the *Caninae* the scales on the shaft in its widest part are generally elongate.

CANINAE

The genera are easily separated by an examination of the whole shaft under the microscope.

KEY TO THE GENERA

Protective Hair

1 *a*. Scale index at middle part of the hair greater than 0.3.....*Urocyon*
b. This index less than 0.3.....2
2 *a*. Seldom more than two "courses" of cells across the medulla.....*Vulpes*
b. Seldom less than four "courses" of cells across the medulla in the widest part of the shaft.....3
3 *a*. Medulla about 60 per cent of the shaft diameter at its widest part.....*Alopex*
b. Medulla more than 75 per cent of the shaft diameter at its widest part.....*Canis*

Fur Hair

1 *a*. Pockets of pigment between the medullary cells..... ..... *Canis*
b. These pigment pockets lacking.....2
2 *a*. Scales strongly elongate at the base of the hair....3
b. Scales not strongly elongate at the base of the hair..... *Vulpes*
3 *a*. Medulla usually more than 50 per cent of the diameter of the shaft at its widest part..... *Alopex*
b. Medulla seldom approaching 50 per cent of the diameter of the shaft at its widest part..... *Urocyon*

Note.—Bracket three in the above breaks down too frequently to be of much use, but the rarity of *Alopex* and its range will often eliminate that genus.

VULPES

The Red Foxes

PROTECTIVE HAIR

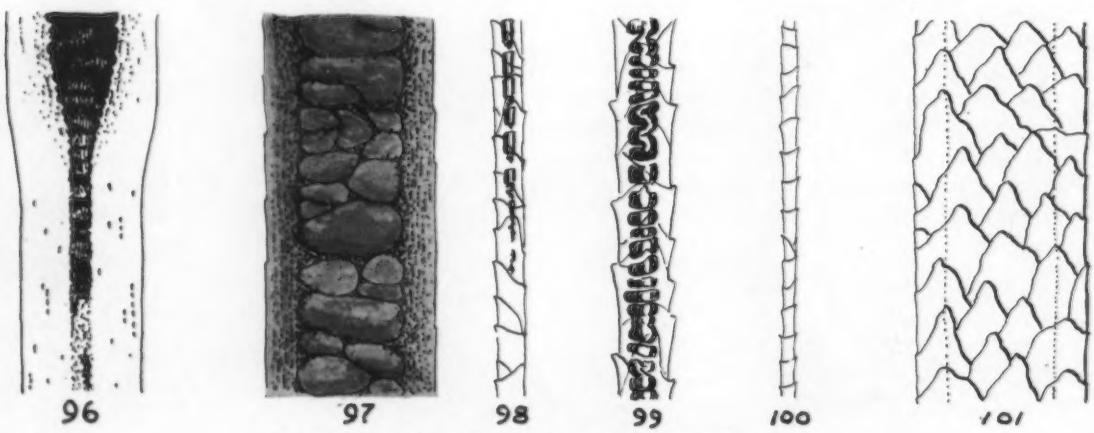
COLOR: usually rusty red to buff, occasionally black, brown, grizzled or white.
LENGTH: up to 8 cm.
DIAMETER: 108μ–220μ; mean 153μ.
SCALES: difficult to see; slightly elongate, crenate margins, basal scales strongly produced. *Indices:* base 0.17 (120μ), basal 0.28 (116μ), mid-section 0.19 (104μ); widest part 0.10 (152μ).
CORTEX: lightly stained yellow; pigment granules are small and vary in quantity and color, light reddish brown to rich brown.
MEDULLA: *index:* 0.74 (0.60–0.84).
Form: the medulla is composed of rather uniform sized cells of modified globular shape with occasional large flat cells. In the widest part of the shaft the medulla frequently takes on an entirely different aspect. In these instances the majority of the cells are so compressed as to appear like thin wafers across the medulla. In this a few of the cells retain their more or less globular form. This is the usual type of medulla in the genus *Lynx* where the non-flattened cells are very large. These globose cells in *Vulpes* are generally small and seldom exceed one-third of the medullary diameter in their greatest dimension.
Pigment: intercellular.

FUR HAIR

COLOR: colorless or yellowish.
LENGTH: about 2 cm, kinky.
DIAMETER: 20μ–40μ; mean 26μ.
SCALES: prominent, smooth margined.
Index: 1.0 (24μ).
CORTEX: free of pigment, usually free of stain.
MEDULLA: *index:* 0.70 (0.60–0.80).
Form: continuous column of cylindrical plinths.
Pigment: absent.

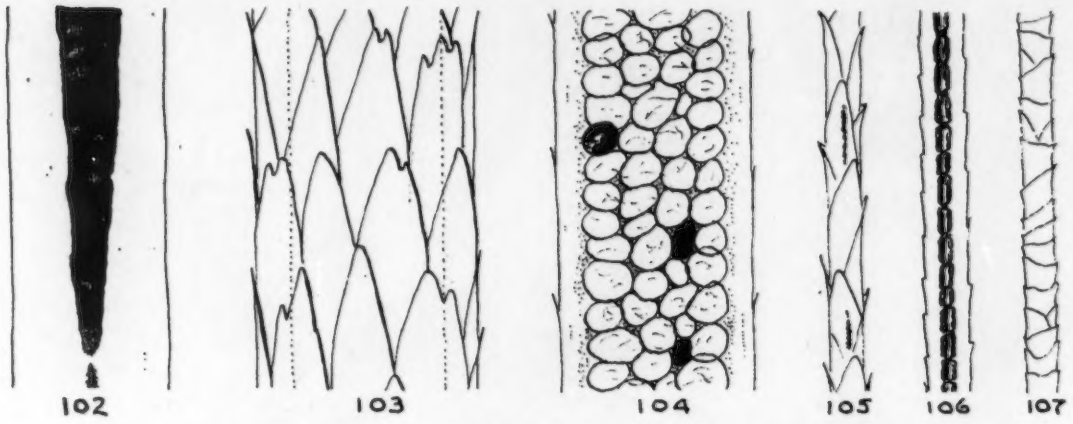
IMPORTANT CHARACTERISTICS

The color of the pigment granules is rarely met in hairs with which these might be confused. In the case of *Lynx* the size of the inflated cells in the medulla at the widest part of the shaft will give the cue. They are much smaller in *Vulpes*. From *Urocyon* the dark hairs may be separated by the prominence of the cuticular



FIGS. 96 TO 101. *Vulpes velox velox* (Say) ERW 4367.

FIG. 96.....protective...base....80μ–100μ
FIG. 97 pigmentation reduced for clarity.....protective...mid.....108μ
FIG. 98.....fur.....base.....16μ
FIG. 99.....fur.....mid.....40μ
FIG. 100.....fur.....tip.....9μ
FIG. 101 detail of scales..protective...mid.....112μ



FIGS. 102 TO 107. *Urocyon cinereoargenteus scotti* (Mearns) ERW 2918.

FIG. 102	protective	base	104μ	FIG. 105	fur	base	32μ
FIG. 103 detail of scales	protective	mid	144μ	FIG. 106	fur	mid	28μ
FIG. 104	protective	mid	128μ	FIG. 107	fur	distal	20μ

scales in that genus. From *Canis* the pigmentation of the fur hair in that genus and the generally coarser protective hair will serve. From *Alopex* in the summer pelage the generally light pigmentation in *Alopex* is practically diagnostic. From *Felis* the scales will point the way.

UROCYON

The Grey Foxes

PROTECTIVE HAIR

COLOR: usually grizzled black and white, dirty white on belly, occasionally reddish on flank or neck.

LENGTH: usually up to 7 or 8 cm, rarely to 10 cm.

DIAMETER: 140μ–268μ; mean 189μ.

SCALES: the cuticular scales are generally prominent through the shaft except for the very tip. They are strongly elongated and have smooth margins except for a notch at the apex. *Indices:* base 0.46 (152μ), basal 0.39 (148μ), mid-section 0.46 (144μ), widest part 0.10 (228μ).

CORTEX: faintly stained yellow; pigment granules dark brown; fusi not uncommon.

MEDULLA: *index:* 0.74 (0.63–0.80).

Form: continuous, rarely assuming the *Lynx*-like form as in *Vulpes*.

Pigment: present.

FUR HAIR

COLOR: colorless.

LENGTH: about 3 cm.

DIAMETER: 24μ–40μ; mean 30μ.

SCALES: easily seen, smooth margined. *Indices:* 1.4 (28μ), 0.7 (36μ).

CORTEX: free of stain and pigment.

MEDULLA: *index:* 0.53 (0.37–0.62).

Form: as in *Vulpes* q.v.

Pigment: absent.

IMPORTANT CHARACTERISTICS

From *Taxidea*, with which the hair might be confused in gross aspect, the scalation will serve to identify *Urocyon*. From the other *Canidae* the important characteristics are noted in the foregoing key. The peculiar medulla of *Lynx* will serve to separate that genus from *Urocyon*.

ALOPEX

The Arctic Fox

PROTECTIVE HAIR

COLOR: white, or dirty brown, rarely slate grey.

LENGTH: 7 to 8 cm.

DIAMETER: 56μ–132μ; mean 85μ.

SCALES: like *Vulpes* q.v. *Indices:* base 0.78 (52μ), widest part 0.32 (88μ).

CORTEX: faintly stained yellow; no pigment in white hairs. (I have not examined summer or slate-colored specimens.)

MEDULLA: *index:* 0.61 (0.33–0.76).

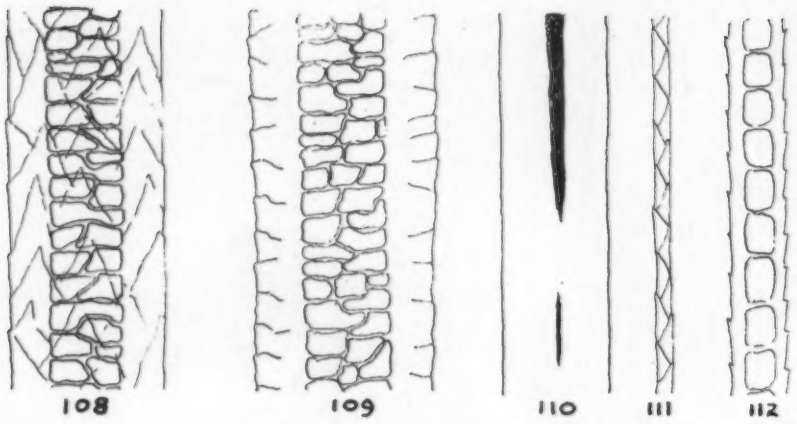
Form: continuous.

Pigment: large dark brown granules scattered between cells.

FUR HAIR

COLOR: white.

LENGTH: 2–3 cm.



FIGS. 108 TO 112. *Alopex lagopus ungava* (Merriam) AMNH 19481.

FIG. 108.....protective...basad.....100μ
FIG. 109.....protective...mid.....120μ
FIG. 110.....protective...distal.....72μ
FIG. 111.....fur.....base.....12μ
FIG. 112.....fur.....mid.....32μ

DIAMETER: 20μ–60μ; mean 30μ.
SCALES: smooth margined. *Indices:* 1.6 (20μ), 1.0 (36μ).
CORTEX: free of pigment and stain.
MEDULLA: *index:* 0.57 (0.40–0.69).
Form: as in *Vulpes* q.v.
Pigment: absent.

IMPORTANT CHARACTERISTICS

The following will separate the hairs of *Alopex* from those of *Thalarctos:* the diameter of the protective hair of *Thalarctos* is much greater, while the proportionate diameter of the medulla is much less than in *Alopex*.

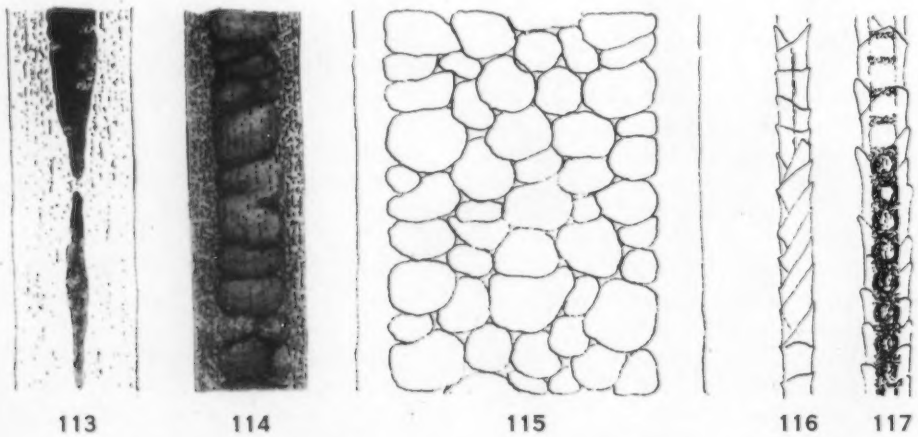
The following will separate the hairs of *Alopex* from *Lepus:* the medulla of *Lepus* is easily recognized by its "ear of corn" appearance and occupies over 80 per cent of the shaft.

CANIS

The Dogs, Coyotes and Wolves

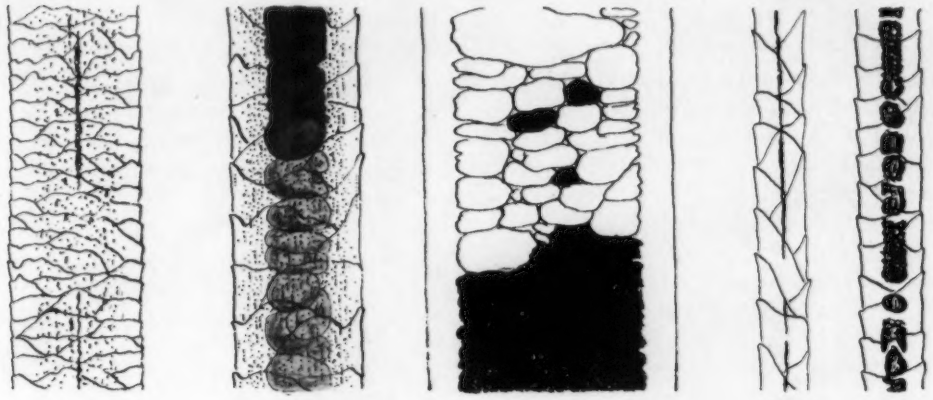
PROTECTIVE HAIR

COLOR: variable, usually grizzled in wild species.
LENGTH: up to 7 cm.
DIAMETER: 156μ–228μ; mean 191μ.



FIGS. 113 TO 117. *Canis nebrascensis nebrascensis* (Merriam) ERW 770.

FIG. 113.....protective...base.....80μ
FIG. 114.....protective...basal.....76μ
FIG. 115 all pigment omitted.....protective...mid.....228μ
FIG. 116.....fur.....base.....20μ
FIG. 117.....fur.....mid.....32μ



FIGS. 118 TO 122. *Felis oregonensis hippolestes* (Merriam) CMNH 2776.

FIG. 118.....protective...base.....84μ
FIG. 119.....protective...basad.....84μ
FIG. 120.....protective...mid.....164μ
FIG. 121.....fur.....basal.....32μ
FIG. 122.....fur.....mid.....40μ

SCALES: like *Vulpes* q.v. *Indices:* basal 0.21 (160μ), mid-section 0.10 (180μ).
CORTEX: stained dirty yellow to reddish brown; pigment granules dark brown in dark parts of shaft.
MEDULLA: *index:* 0.69 (0.55–0.88).
Form: continuous, tapers sharply at base.
Pigment: present.

FUR HAIR

COLOR: colorless to dingy brown.
LENGTH: about 4 cm, wavy.
DIAMETER: 28μ–100μ; mean 55μ.
SCALES: easily seen. *Indices:* 1.25 (36μ) to 0.15 (96μ).
CORTEX: free of pigment, sometimes stained.
MEDULLA: *index:* 0.48 (0.28–0.65).
Form: as in *Vulpes* q.v.
Pigment: intercellular clusters of dark brown granules.

IMPORTANT CHARACTERISTICS

There are no clear-cut characteristics that will infallibly separate the hair of *Canis* from that of the rest of *Canidae*. However the combination of characters given above seems to be reliable.

FELIDAE

FELIS

The Large Cats

PROTECTIVE HAIR

COLOR: tawny; darker hairs occur on some southern species.
LENGTH: about 6 cm.
DIAMETER: 132μ–208μ; mean 167μ.
SCALES: flattened, crenate. *Indices:* base 0.14 (84μ), basal 0.42 (84μ), widest part 0.07 (172μ).
CORTEX: stained light yellow, filled with translucent granules of orange-brown pigment.
MEDULLA: *index:* 0.62 (0.47–0.70).
Form: continuous.
Pigment: absent.

FUR HAIR

COLOR: pale buff.
LENGTH: 3 cm.
DIAMETER: 28μ–112μ; mean 58μ.
SCALES: smooth margined, slightly elongate in basal portion. *Indices:* basal 1.3 (32μ), mid-section 0.28 (48μ).
CORTEX: as in protective hair.
MEDULLA: *index:* 0.42 (0.25–0.47).
Form: continuous column of cylindrical plinths, often fragmentary toward tip.
Pigment: present.

IMPORTANT CHARACTERISTICS

The orange-brown pigment granules and the dimension of the hair will usually be found satisfactory for identifying the hair of this genus within our range.

LYNX

Bob-cats

PROTECTIVE HAIR

COLOR: generally grizzled grey, brown and black.

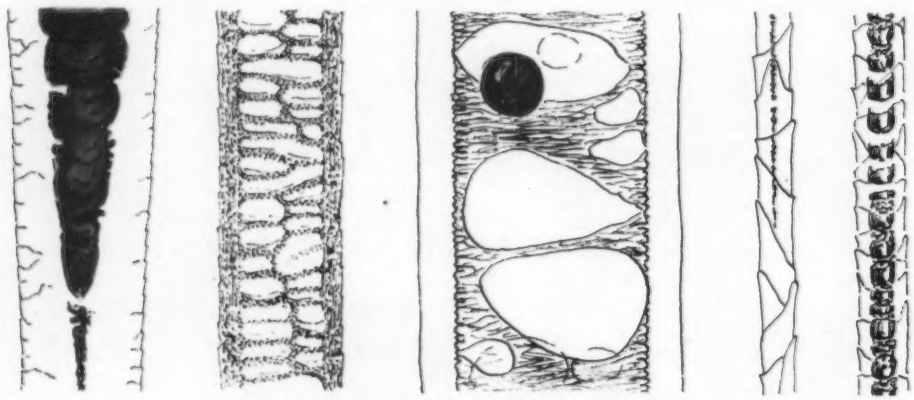
LENGTH: 5 cm.
DIAMETER: 88μ–184μ; mean 152μ.
SCALES: slightly flattened with a wavy margin. *Indices:* basal 0.14 (88μ), widest portion 0.04 (176μ).
CORTEX: stained yellowish, well supplied with dark brown granules.
MEDULLA: *index:* 0.75 (0.67–0.83).
Form: continuous, composed of very large globose cells that occupy the full diameter of the medulla between which are packed thin wafers of material that may be collapsed cells.
Pigment: very fine granules present.

FUR HAIR

COLOR: greyish or light buff.
LENGTH: 4 cm.
DIAMETER: 16μ–40μ; mean 27μ.
SCALES: prominent, smooth margined, elongate, especially toward the base. *Indices:* 1.05 (20μ), 0.67 (24μ).
CORTEX: free of stain, rarely with a few pigment granules.
MEDULLA: *index:* 0.55 (0.37–0.70).
Form: same as *Felis* q.v.
Pigment: intercellular clusters of dark brown granules.

IMPORTANT CHARACTERISTICS

The peculiar structure of the medulla coupled with the diameter of the shaft is diagnostic for the protective hairs of *Lynx*.



FIGS. 123 TO 127. *Lynx baileyi* (Merriam) ERW 751.

FIG. 123.....protective...base....76μ–100μ FIG. 125.....protective...mid.....172μ
FIG. 124.....protective...basad.....80μ FIG. 126.....fur.....base.....20μ
FIG. 127.....fur.....mid.....32μ

THE EFFECT OF EARLY AND LATE BRAIN INJURY UPON TEST SCORES, AND THE NATURE OF NORMAL ADULT INTELLIGENCE

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ABSTRACT

This paper presents an hypothesis concerning the nature of normal adult intelligence. The hypothesis is based in part on the recognized clinical fact that brain injury affects test scores unequally, and in part on the apparent fact that this is less true of injury in early infancy: early injury, that is, may have a less selective and more generalized effect than late injury. The purpose of this review of the effect of brain injury on test scores is first to establish that there is such a difference in the effects of early and late brain injury, and secondly to show that the difference has meaning for the theory of intellectual development. It is proposed therefore (1) to examine the evidence concerning the effect upon test scores of late injury, without aphasia, and (2) with aphasia; (3) to compare these effects with that of birth injury, as far as they are comparable; and (4) to present an hypothesis of the development and retention of intelligence.

The hypothesis had its origin in the apparently isolated clinical problem of trying to account for certain high test scores made by patients with large cerebral destructions, but it has been found also to account for certain features of normal intelligence, and particularly for some of the characteristics of senescence.

THE EFFECT OF LATE INJURY OUTSIDE THE SPEECH AREAS

SINCE the characteristics of aphasia are so unlike those of non-aphasic deterioration, the test scores made by aphasic patients will be considered in a separate section. For the effect of brain injury without aphasia, there are several sources of information. One is the fairly large number of cases of brain operation in which the Stanford-Binet has been used, sometimes both before and after operation. Although there are serious drawbacks to its use for the purpose, the high validity of much of its content with normal subjects gives a special interest to the scores of brain-operated patients.

[1] Acknowledgments are due to Drs. Wilder Penfield, W. V. Cone and Arthur Elvidge for assistance and advice in the study of cases at the Montreal Neurological Institute; to Dr. Heinz Werner for further case material from the Wayne County Training School; and to Dr. Edgar A. Doll, Prof. K. S. Lashley and Prof. G. Humphrey for assistance and criticism in the preparation of this paper.

STANFORD-BINET SCORES IN CASES OF BRAIN OPERATION

I have been able to find reports of Stanford-Binet *IQ*'s after adult brain operation in 15 cases reported by the following authors: Ackerly (1935; the statement that the patient's score was "as good as the average" is taken to mean an *IQ* of 100); Brickner (1936); German and Fox (1934); Halstead (1940); Nichols and Hunt (1940); Lidz (1939); Penfield and Evans (1935); and Rowe (1937). This excludes non-surgical cases and children. The mean *IQ* for this group of 15 patients is 108, with scores ranging from 82 to 139 (not much weight can be given to the exact figures since in some cases the old Stanford-Binet was used, in others the new). In addition, I have records[2] of 23 patients examined at the Montreal Neurological Institute with the new Stanford-Binet; the average here is 107, with scores ranging from 54 to 152. For the total group of 38 cases the mean score is 108. Since the true norm for adults is probably below 100, there is evidently some selection operating to give us an above-average group—how much above average, in original level, there is no way to tell.

Again, five of the writers cited above give pre- and post-operative scores. In none was there post-operative loss. For 14 cases from the Montreal Neurological Institute with pre- and post-operative examination there was a mean loss of 1.3 points in *IQ* following operation. For the total group of 19 cases the mean drop in *IQ* is 1 point, the individual results ranging from a loss of 14 points to a gain of 11 points. Of the 19 cases, 7 show a loss, 6 a gain, and 6 no change following operation. Is this apparent lack of effect due to the compensating removal of dysfunction, with the effect of surgical destruction balanced by recovery from the pre-operative disturbance? To some extent, presumably; but in the cases from the Montreal Neurological Institute the pre-operative status was good (in each case the operation was

[2] Some of these cases have been reported elsewhere (Hebb, 1939, 1939*a*, 1941; Hebb and Penfield, 1940).

for the purpose of removing scar tissue), and the case reports of other writers suggest the same thing. The data do not give an exact knowledge of the effect of cerebral destruction, *per se*, but they do suggest strongly that destruction outside the speech areas has no great effect on Binet score. We shall see later that this is not confined to cases of smaller excision.

Analyses by Weisenburg and McBride and by Rylander

Actually, the Binet-type test measures a number of abilities, and two important studies show the necessity of considering these abilities separately. Weisenburg and McBride (1935), in a study incidental to their larger work on aphasia, and Rylander (1939) have made extensive analyses of test abilities following cerebral injury.

In both studies the anatomical data leave something to be desired for the purpose of relating the defects to the type and extent of destruction. Weisenburg and McBride's group apparently consisted mostly of cases of diffuse pathological destruction due to vascular change and 19 of their 22 subjects were hemiplegic. Rylander's were all cases of operative lesion, but his case reports show definitely that a number of the patients examined had more or less extensive areas of pathological destruction in addition to the surgical removal: the 32 cases included cases of incomplete tumor removal, cases of infiltrating tumor (which usually recur and which are especially effective in causing mental changes), and one case in which the anterior cerebral artery was believed to have been shut off at operation. Weisenburg and McBride's work, therefore, is primarily a study of the effect of diffuse pathological destruction, the extent of which is not known; Rylander's a study of the effect of frontal pole removal together with an unknown amount of pathological destruction.

The importance of these studies is partly due to their use of good normal control groups, as well as to the fact that their analysis of the mental change is based on the independent measurement of a number of abilities. Rylander apparently succeeded in matching his clinical group very closely for age, occupation, and education. Weisenburg and McBride were able to match their right-hemisphere, non-aphasic group for age only; this makes for difficulty in fixing the amount of absolute loss, but not in fixing the loss in one ability relative to another.

The first question to be asked concerns the effect of cerebral injury on vocabulary score, which appears to stand in a special category in relation to mental deterioration. It seems unaffected in schizophrenia; at any rate, it is likely to be the highest score relative to normal levels (Babcock, 1930). In the gradual loss of test ability with age, it again remains the highest, or one of the highest, abilities (Jones and Conrad, 1932; Weisenburg, Roe and McBride, 1936; Wechsler, 1939), and Shakow and Goldman (1938) have shown that this is probably a retention of original adolescent level up until the sixties. Vocabulary is commonly found to be the highest score on the Stanford-Binet in adults who give evidence of mental loss following gross brain injury.

Direct evidence on the effect of frontal lobe injury on vocabulary is given by Rylander, who found no significant difference in the scores of normal and frontal lobe groups. The evidence of Weisenburg and McBride is in agreement; apart from tests of academic achievement, oral vocabulary score is the highest in the averages of their right-hemisphere group and about on a level with occupational and educational indices. Rylander's data actually make a slight loss probable, and Shakow and Goldman show that there is loss with advanced age over sixty. Vocabulary therefore is retained nearly at a normal level in deterioration, but is not completely unaffected.

When it is asked what tests, on the contrary, show the greatest effect with cerebral injury, it is harder to give an answer. Rylander unfortunately used no speeded non-verbal test which, from the indications of senescence and of schizophrenic deterioration, should show the greatest effect. Weisenburg and McBride did not have speeded non-verbal tests sufficiently sensitive for their normal group, but did find that right-hemisphere lesions depressed performance in those that were used. There seems to be no simple classification of kind of test score most affected in these studies. Rylander, for example, finding no effect on oral vocabulary, found also a loss of ability to give differences between abstract words. On the surface, at least, these results are hard to reconcile. Weisenburg and McBride, again, found the greatest effect shown by a purely verbal, unspeeded task, the Kelley-Trabue Language Completion; the next greatest in an unspeeded non-verbal task, the Porteous Maze. It seems likely that individual differences (of original test-score pattern) confuse the results. It is also likely that the locus or type of lesion may be important. One ability may be affected more by temporal-lobe than by frontal-

lobe lesions; another more by epileptoid dysfunction than by simple loss of tissue. Weisenburg and McBride's group was anatomically dissimilar to Rylander's, and neither was anatomically homogeneous. It is probably too much to expect, from what is known at present, that the picture of deterioration in anatomically different cases will be very similar. It is only surprising that we can name one ability—vocabulary—that consistently remains near its original level in deterioration. No similar generalization seems possible concerning the abilities or kind of ability affected most.

Individual Cases of Large Lesion or Marked Deterioration

The evidence discussed so far has been from cases of diffuse pathological destruction or relatively small surgical removals, and cases in which deterioration is not outstanding but evaluated by taking averages for large groups. Another approach to the question of the effect of brain damage is found in cases of unusually large surgical destruction or cases in which there has been marked deterioration.

The outstanding case is that of Rowe (1937). Dr. Rowe, in a personal communication, has furnished further details of the Stanford-Binet examination of his patient after removal of the entire right hemisphere above the basal ganglia. These details are very valuable. Dandy (1928), Gardner (1933) and O'Brien (1936) have reported cases which are similar surgically, but without psychometric examination. In such cases the bare statement that the patient showed "no obvious mental defect" must be particularly unconvincing to a psychologist, and a common-sense appraisal of intellectual ability may be especially fallible after brain injury (Hebb, 1939). Yet for certain aspects of intelligence it is impressive to find independent observers reporting that there was little or no mental change after operation. The repeated statements of relatives or acquaintances that they found no defects cannot be wholly dismissed: they indicate that some of the components of adult intellectual ability are at most slightly affected. The psychometric data given by Rowe support this strongly. His patient had unfortunately become sensitive about her intellectual powers (after loss of half the cerebral cortex!) and was also found to tire very easily; the examination was not completed, but the results, while they do not make it possible to calculate an *IQ*, are of great significance.

The examination (with the old Stanford-Binet) was begun with Year XVI, test 3, "Differences between abstract words". The test was solved "very readily", and the examiner shifted to Year XVIII. A score of 46 with one vocabulary list was made. "She was able to repeat one out of the series of eight digits forward, and one of the seven reversed. Her summaries for both of the (memory) passages in test 4 were judged satisfactory. Her solution of test 6 was correct in (b)."

This was the third time the test had been given the patient (others before the complete hemidecortication), but more than a year had elapsed since the second examination, and it seems impossible to explain such a performance by practice effect, in the presence of any serious, generalized intellectual loss. The repetition of digits, forward and backward, should alone be enough to show that for some things the patient's abilities were above the average for the general population. It is clear, of course, that these data do not mean that other abilities were unaffected. We have already seen that the retention of one ability does not mean that others are also equally retained, and the psychometrist's report, that the patient "fatigued fairly rapidly, both physically and mentally" is positive evidence that in certain other tests the patient would have made lower scores. The significant fact here is the objective evidence supporting the clinical opinion that the patient's abilities were in some respects well retained; and the fact that even if other test abilities were impaired the patient still had average or above-average ability in the kind of task which is the core of the Binet test. Such things as comprehension of words, differentiation of abstract terms, memory for complex verbal material and solution of reasoning problems, are the kind of task which is most successful in differentiating various levels of intellectual development in normal subjects.

In Rowe's case the cerebral destruction was, of course, unilateral. In the following case from the service of Dr. W. V. Cone of the Montreal Neurological Institute, the destruction was not as large nor as well defined, but was on the other hand bilateral; and an extended examination was carried out although visual defects prevented the use of some test material.

Case 1.—H. D.; 15 yrs. 11 mos.; male, right-handed. The patient had a history of drainage of brain abscess in the right temporal region, with transient hemi-paresis, followed by epileptic attacks and gradually impaired vision. Two more abscesses were reported to have been drained, "a

pint of pus" from one of them, followed again by left hemi-paresis and complete blindness. The parents reported that he had become "slightly dull" mentally at this time.

On admission in April, 1939, an encephalogram showed a "huge right-sided expanding intracranial lesion" in the right temperoparietal region. Drainage of multiple abscesses, before and behind the foot of the central fissure, was done by Dr. Cone two days later, followed by treatment with sulfapyridine. In the following four months there was a gradual increase of voluntary movement of left arm and leg, and some recovery of vision. Three months after operation, 1 month before examination, there was a grand mal attack.

FIG. 1.

A post-operative encephalogram (Figs. 1 and 2) showed him at this time to have a very large defect of the right hemisphere, and a smaller defect of the left. The ventricle was in communication with the subdural space in the right hemisphere in its dorso-parietal aspect. Dr. Arthur Childe, radiologist, and Dr. Cone agreed on stereoscopic study of the X-ray plates that the destruction on the right side was certainly 40 per cent, possibly 50 per cent of the total mass of the right hemisphere, and that the destruction of the left (by pressure only) was at least 20 per cent of the left hemisphere. This would mean a diffuse destruction of 30 to 35 per cent of the mass of the cerebrum—20 to 25 per cent on the right, 10 per cent on the left side. Since the estimation of quantity was difficult, it may be said that the destruction was not less than 20 per cent, and probably more than 25 per cent of the mass of the cerebrum, with an upper limit of probably 35 per cent, possibly as high as 40 per cent.

The patient's psychological status appeared to be exceptionally good. The one defect, by informal observation, was his inactivity, and apparent willingness to do nothing for rather long periods. But in conversation he seemed normally alert and responsive, and quite co-operative. His memory was good; he knew the names of nurses who spoke to him, and after being told the examiner's name once remembered it readily the next day. He knew the date, the name of the hospital and the city he was in; the name of the present king of England, George VI, of the preceding king (Edward VIII) and the approximate date of George V's death. He answered questions about approximate distances of his home from other cities correctly and readily.

Psychometric examination was limited by his almost complete visual defect. The Stanford-Binet, form L, was given, omitting tests involving vision. The vocabulary score was 21, at the Average Adult level, and he succeeded with two tasks at a higher level, the repetition of 8 digits forward (SA II) and 6 digits backward (SA I). At the Average Adult level, in addition to the vocabulary success, he succeeded with differences between abstract words and repetition of sentences. At Year XIV, he failed the Orientation test, but succeeded with Ingenuity and Abstract Words. At Year XIII he succeeded with the two non-visual tasks, Problems of Fact and Memory for Words; at XII, failed one of 4 non-visual tasks, the Verbal Absurdities; at XI, succeeded with all non-visual tasks; at X, failed one, Finding Reasons; and at IX, succeeded with the four non-visual tasks.

From the Weisenburg and McBride battery, he was given the Oral Analogies test, making a score of 9; and Oral Opposites, with a score of 14, time score 120 seconds. These three scores fall near the lower limits of Weisenburg and McBride's normal range; the repetition of digits, forward and backward, and probably vocabulary and difference between abstract words, are above average by the same norms.

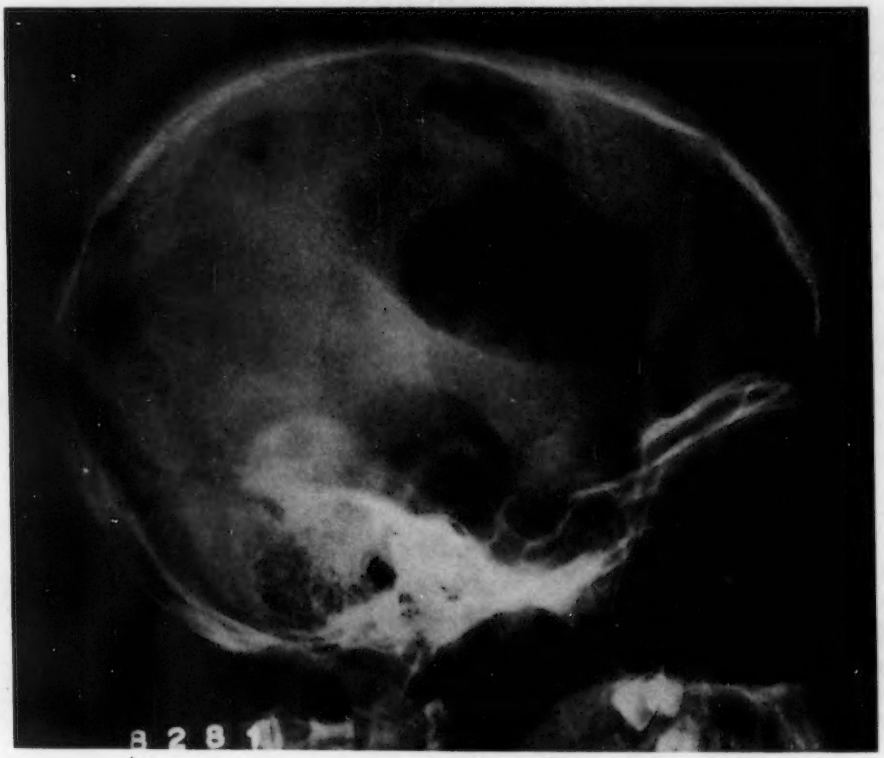

FIG. 2.

One speeded test, the "Tactile Formboard" (experimental, test-retest reliability of 0.70 only), independent of vision and standardized for the use of one hand, was given. Here again his score was at the lower quartile of a normal group.

There are some grounds for making an estimate of the original level of ability in this patient. There is first the vocabulary score, and the fact that answers in this test were given promptly and without evidence of difficulty of expression with words which the patient understood. There was no "scatter" (if the term may be used here) in the test: there was success with the first 17 words, with a prompt, but wrong, definition of the eighteenth ("Priceless: not worth anything"), and success with the nineteenth, "Disproportionate"; no. 20, the patient said he didn't know; no. 21, "shrewd", was defined wrongly; "tolerate", no. 22, could not be defined; no. 23, "stave", was correctly defined as part of a barrel; no. 24, "lotus" was first unrecognized, then the patient said it might be a flower; no. 25, "bewail", was defined correctly; and no further successes were obtained. The pattern of success and failure seemed to be that of a normal individual. The performance of a patient was not to be distinguished qualitatively from that of a normal subject of the same level. He was alert and responsive throughout. These considerations make it probable that the score of 21 on the new Stanford-Binet vocabulary list is fairly representative of the original level of the patient. It corresponds to an *IQ* slightly above 100. The school record, as given by the patient's mother, also corresponds. He passed into grade VII at the age of 14, having failed once in grade VI. He "hated school", but seems to have done reasonably well there—with an average record for the son of not very intellectually-inclined parents, in a small country town.

It appears then that in repetition of digits, forward and backward, in memory for sentences, differences between abstract words and "Ingenuity" the patient also retained something close to the original level of ability after diffuse loss of 20–40 per cent of the mass of the cerebrum. The value of the case is to be found in its combination of a really extensive lesion, involving the left as well as the right hemisphere, with an unusually good retention of subjective clarity, responsiveness, memory and apparent coherence of thought processes,

as far as these were evident in his conversation. In the examiner's judgment, these aspects of intelligence were unaffected, and there is support for this opinion in the Stanford-Binet record.

The cases just discussed had their special interest because of the retention of certain attributes of intelligence—responsiveness, powers of directed effort, comprehension of verbal material and memory—in spite of exceptionally large cerebral lesions. Occasionally the retention of these abilities is of special interest not because of the size of the patient's injury, but because the injury has induced a sharp loss in other abilities. When the psychologist has an opportunity to examine such a patient, he knows at least that he is dealing with a brain injury which is capable of seriously affecting "intelligence". In such circumstances, manifestations of superior ability, even in a single case, are significant. The following case is that of a patient operated on by Dr. Arthur Elvidge at the Montreal Neurological Institute.

Case 2.—M. G.; female; 46 years of age; partial removal of bilateral oligodendroblastoma in the frontal region, with post-operative confusion, defects of immediate memory and euphoria. At operation Dr. Elvidge made a right frontal pole amputation, and estimated that about two thirds of the tissue of the frontal lobes was destroyed by the neoplasm and the surgical procedures. The neoplastic tissue could not be completely removed because of the patient's condition. Dr. Elvidge believed that the right, and possibly both anterior cerebral arteries were clipped at operation.

Following operation, with deep X-ray therapy, there was marked improvement in the patient's condition. There were no sedatives given during the period of psychological examination, (third and fourth weeks after operation) but the X-ray therapy and the frequently high intra-cranial pressure undoubtedly contributed to the post-operative confusion. The patient was "cheerful to excess", alert and co-operative until the time of discharge to another hospital, four weeks after operation. There were also signs of facetiousness, but this and the slight euphoria had decreased somewhat by the fourth week. About two years after operation it was reported that the patient was much better and doing her housework, but no details were obtained.

The only formal psychological test used was the Stanford-Binet, form L, omitting tests involving vision, because of the patient's low acuity (6/30). The vocabulary score was 26, at the Superior Adult II level—the only success at this level. At Superior Adult I, the patient added success with Sentence Building; at Average Adult, Memory for Sentences; at Year XIV, Ingenuity, Orientation and Abstract Words II. Below this level all non-visual tests were plus. So far this is the record of an intelligent person. But other aspects of intelligence were sharply affected: more so when the intracranial pressure was high, but still affected when it was not. Lying near large windows which lighted the ward during the day, the patient could not say whether it was day or night. She was usually unable to say whether it was winter or summer, what part of the day it was, or whether she had had her lunch, although the tray might have been taken away only a few minutes before. These are the phenomena of "loss of immediate memory", but there is something more than memory involved here. The patient's vision was adequate to a description of the details of the Stanford-Binet picture absurdities, but until she was asked to describe them she did not detect the absurdity; then only in some of the simpler pictures. Her vision was certainly enough to let her see whether the window was the source of light or not, but did not tell her whether the time was day or night.

On the other hand, the patient had an excellent immediate memory for some things. The name and the distinctive step of the examiner was remembered, and the names of several of the house staff. She was oriented as to place most of the time—the Neurological Institute was the "Neuro-something Institute", although at other times she thought she was in a small hospital near her home.

In such a case the mental defect is restricted. Unfortunately, the patient was discharged to another hospital before other tests were used, and with these a somewhat wider zone of defect might have been shown. In any case, it would be hard to draw a line of demarcation about the region of intellectual loss. The facile explanation by loss of immediate memory is not satisfactory. On the one hand, immediate memory for some things was good; on the other, something more than memory was involved. No normal individual in a room lighted by a large window would have trouble knowing that it was day and not night. As in other cases in which at first glance there appears to be a simple loss of one function with retention of others, closer examination shows that this is not so. We have not yet found the conceptual categories for the description of behavior which will allow us to say that this ability is affected alone, or that one ability is gone completely while others are

retained. The tests available for the analysis of mental ability are impure and the relation of test abilities to the brain probably not such that injury can eliminate one without affecting others. The phenomena of the case just reported are not unusual; what is less common is the extent of the contrast between the subject's mental activity, alertness and retention of certain test abilities, on the one hand, and her serious intellectual disability in another field.

Summary of Test Data in Non-aphasic Cases of Deterioration

The evidence from the larger groups of cases, and from the individual cases cited here, agrees on one point. Ability to do certain tasks which form an important part of Binet-type tests may not be greatly affected even by large injuries to the mature brain: these tasks include word definition, comprehension of and memory for complex verbal material, and the solution of unspeeded verbal problems which are hard to classify apart from the fact that they appear to be of a familiar kind, dealing with matters of general significance (though even this may not be true in all instances). The evidence shows also that there is likely to be deterioration in other abilities, although the extent and kind of loss in any individual case is unpredictable. The particular tests which have been found to show the effect of late brain injury, in the various cases cited, include: maze tracing, sentence completion, differentiation of abstract words, giving of opposites, analogies, speeded block-manipulation tasks, and picture absurdities.

Vocabulary is most noteworthy as an ability which is at most slightly affected; in all probability there are other things which are as well retained, but which are not measured directly by existing tests. This is suggested by the repeated and emphatic clinical statement that "intelligence" has been unaffected by surgical removal of cerebral tissue. The statement cannot be taken at face value, but it is presumptive evidence that important components of normal adult ability are well retained.

The Special Case of Aphasia

This paper is not concerned with the question whether aphasia involves a loss of "intelligence" or not. The question is still the subject of controversy, partly because the various writers obviously have different ideas as to what intelligence is. Head's conception, that aphasia involves defects of symbolic formulation and expression, seems generally accepted: on the face of it, this is an intellectual defect, and has been so interpreted by some writers. But others, who have been able to show that the aphasic may be very competent in some matters involving intelligence, argue that only a special power and not intelligence is lost. The argument makes intelligence a unitary thing, which is retained or impaired as a whole. In normal individuals, this may be an acceptable point of view; for clinical subjects it is untenable. The evidence already reviewed shows that it is possible after brain injury to have sharp loss of one ability side by side with a high level in others. This paper therefore is concerned with the nature of the actual test scores made in aphasia, not with the meaning of possible defects, or with the question of how "intelligence" is to be defined.

In one point, however, it will be desirable not to take test scores at their face value. Kennedy and Wolf (1936) have pointed out that many of the so-called non-verbal tests used in the study of aphasia are not, in fact, non-verbal, but involve understanding the language of the instructions. The task is non-verbal, but the method of directing the subject is not. If he only partly understands the directions or is slow in understanding them, he may be seriously handicapped.

To minimize this difficulty of method, tests are desirable in which there is (1) a practice period in which the examiner can make sure that the subject knows what to do, and has adjusted himself to the task; (2) a graduated series of tasks of the same kind as those of the practice series, in which no new directions are given, and in which success with the first, easy items would show that the practice period had achieved its purpose. It would also be desirable to have (3) some tests in which speed is unimportant, as a further guarantee that low scores are not due merely to a slow adjustment by the subject.

The chief source of psychometric data on aphasia is the study of Weisenburg and McBride (1935). This study was handicapped by a lack of suitable non-verbal tests, and therefore the results are open to the criticism of Kennedy and Wolf. Nonetheless Weisenburg and McBride make it improbable that the low non-verbal test scores of aphasic patients are due only to failure to understand directions. Some of their tests partly meet the requirements I have suggested above: the Seguin Form Board, in which the subject has three trials, his score being the time for the most rapid

solution only; the Knox Cube test, and the Porteous Maze, both unspeeded and graduated from easy to hard, but without practice periods. If errors in these two latter tests were made only with the later and more difficult items, success with the easier ones would show that failure was not due to mis-understanding the directions. Unfortunately Weisenburg and McBride do not touch on this point and do not give averages and distributions of scores in individual tests such as those mentioned, or in the Goodenough "Drawing a Man" test.

Some slight further evidence was obtained at the Montreal Neurological Institute, in the course of a preliminary study of the usefulness of an experimental test battery. The data were obtained from 6 cases only, and complete psychometric examination was not done.

Five were cases of "predominantly expressive" aphasia; one a case of amnesic aphasia. Three, including the case of amnesic aphasia, were cases of temporary speech disturbance, lasting from 2 to 10 months, following brain surgery in or near the speech areas; in each of the three, tests made when the aphasia was severe were repeated when it had almost disappeared. Some of the tests were in rough preliminary form, but cast light on the abilities of aphasic patients relative to a rather good normal control group of public ward patients.

Results.—(1) The Knox Cube test first showed apparently no effect of the brain injury—a rather surprising result, since in this test verbalization appears to contribute to the success of normal individuals. The reliability of the test, however, is probably not high. (2) In a modification of the Picture Absurdity test of the Revised Beta Examination (Kellogg and Morton, 1934), using large, clearly drawn pictures, without time limit and with two practice items, all subjects were below the normal lower quartile. For two of the subjects the practice items may not have been effective, but the other four definitely understood what they were to do. (3) The Kohs Block test was given to four patients only. One of these, the case of amnesic aphasia, made a score of 127—above the upper quartile of the normal group; in the other three cases, with severe motor aphasia, very low scores were made, although in two there were definite indications that the task was understood. (4) Finally, in a block-manipulation test (as yet unpublished), with preliminary practice period, graduated series of tasks, and time limit rather than time score, there was definite evidence of loss of ability with aphasia and a rise of ability when the aphasia had almost disappeared. The evidence indicated, however, that the loss was not very great, and the amnesic aphasic with a high score on the Kohs Block test made a high score here.

In summary, this group of 6 patients showed loss of ability in non-verbal tasks, which did not seem due to failure to grasp the instructions. In one non-verbal task, the Knox Cube, there was no evidence of loss (possibly due to low test reliability); in one, Picture Absurdities, loss seemed general, although it is possible that some subjects may have retained their normal level, if this was originally low; in two block-manipulation tests, some subjects showed much greater defects than others, one subject made high scores, and the amount of loss seemed to be not as great as with the Picture Absurdity test, but greater than with the Knox Cube.

These results are in one way the counterpart of those observed in cases of non-aphasic deterioration. There is a close similarity in the tendency toward a selective effect of brain damage. In one case verbal indices are chiefly affected, in the other non-verbal, but in both the psychograph is marked by an essential disparity of scores *that goes, in extreme cases, well beyond the normal range*. The similarity ends here. In non-aphasic deterioration it appears that some abilities are always retained near their normal level; in aphasic deterioration, although a few patients retain some other abilities at a high level, it seems probable that in a majority of cases there are no test abilities without definite deterioration. Kennedy and Wolf (1937) argue that this is because aphasia is apt to be complicated by an added intellectual deterioration not characteristic of aphasia itself, due to the occurrence of lesions outside the speech area as well as inside it. This may be so, and it is quite possible that in those patients whose test scores are all extremely low (a common situation with severe motor defects) we are dealing with *both* aphasic and non-aphasic defects simultaneously. Whatever the explanation, the facts seem to be (*a*) that in aphasia there is frequently a wide disparity of abilities, but also (*b*) that in most cases both verbal and non-verbal indices show evidence of loss.

In any case of adult deterioration, the disparity of abilities may be extreme. In aphasia, above average abilities may be found together with abilities below the normal adult range; in Case 2,

without aphasia, the same thing was observed, and the changes described by Goldstein (1936) suggest that the use of standard tests in his case would have shown a similar situation. This disparity of abilities in adult cases is to be contrasted with what is to be found in cases of birth injury.

Test Scores after Injury to the Infant Brain

The discussion here is confined to cases of "birth injury" in which test-score levels are not primarily determined by sensory or motor defects. The patient with hemiparesis cannot carry out certain tasks properly because of his motor defect; his test score is not then representative of an intellectual level. As far as can be determined, the scores to be discussed were not directly affected by such handicaps.

This makes for a selected sample. Athetosis or hemiparesis is detectable, but a case of cortical destruction without gross symptoms may pass for normal. The known birth-injury population therefore may deviate systematically from the total birth-injury population, so that one cannot compare the average test score of the birth-injured with the average score in cases of adult injury. The unknown degree of selection in the clinical birth-injury population is the principal difficulty of this study, and I shall return to it again.

A less direct comparison may be made, however, through the pattern of test scores. We do not know that the birth-injury sample is representative; but we can ask whether the defects, *when they do occur,* are similar in cases of early and late injury. In adult injury there are two psychometric patterns: the non-aphasic syndrome, with vocabulary in particular high and other abilities low, and the aphasic syndrome, with nonverbal abilities markedly higher than verbal abilities. For all cases of adult deterioration there would be, therefore, a bi-modal distribution of vocabulary scores and of differences between verbal (Binet) and performance scores, one mode due to the inclusion of cases of aphasia, the other to cases of deterioration without aphasia. Are the defects due to early injury at all similar? The available data, in cases of birth injury, are for children or young adolescents, which is another difficulty in making a direct comparison; but it is possible to compare brain-injured children with normal children, and brain-injured adults with normal adults, to see if deviations from the normal in each case are of the same kind, and of the same extent.

By the kindness of Dr. Heinz Werner, I have obtained details of test data in a series of 32 cases of "exogenous" mental defect (Strauss, 1939; Werner and Strauss, 1939), from the Wayne County Training School. These are not even representative of the known birth-injury cases without gross motor handicap, since those with Binet *IQ*'s below 50 were excluded. As it happens, however, the selection here is on the safe side since it operates against the conclusions of this paper—namely, that certain test levels are lower with early than with late injury.

Werner's data include Stanford-Binet scores (in some of the cases the old, in some the new form was used); year level of vocabulary score; Stanford-Binet scatter; and Arthur Performance Test score. With these data I have included four comparable records from the Montreal Neurological Institute. Strauss has described the Wayne County Training School group as including only higher grade defectives, without gross motor handicap. The lack of motor disability makes an important difference between this group and that of Doll, Phelps and Melcher (1932), the object of whose study was of course different.

The chronological age range, in the combined groups, is from 10 to 19 years, and the range of Binet *IQ* from 43 to 99. Vocabulary scores are available for 32 of the 36 cases. Taking the maximal chronological age as 15, Table I gives the differences between chronological age and vocabulary age level. In one case only the vocabulary age is (6 months) higher than the chronological age; the median vocabulary retardation is between 5 and 6 years, the greatest 9 years.

TABLE I

Distribution of Vocabulary Retardation in Months, Obtained by Subtracting Vocabulary Age Level from Chronological Age [1] in 32 Cases of Birth Injury (Data in 28 Cases Provided by Werner)

CA − *VA* [2] (months)	No. of cases	*CA* − *VA* (months)	No. of cases
−12 to −1	1	60 to 71	9
0 to 11	1	72 to 83	3
12 to 23	1	84 to 95	5
24 to 35	1	96 to 107	1
36 to 47	4	106 to 119	3
48 to 59	3		

[1] Range of chronological age was actually 10 to 19, but 15 is taken as a maximum; vocabulary age ranged from less than 6 to 14.

[2] *VA* = vocabulary age.

This is evidence that vocabulary is generally depressed by birth injury. Vocabulary, also, does not tend, as it does with mature injury, to be one of the high Stanford-Binet subtest scores. Two of 30 cases have vocabulary at the highest year-level of successes; 10, on the contrary, have vocabulary scores at the basal age, and the rest are nearer the basal age than the highest year-level of successes. Scatter seems to be somewhat greater than with normal children, but with vocabulary scores tending to be low it is not like the scatter that may be found in adult cases.

TABLE II

DISTRIBUTION OF DIFFERENCES OF BINET AND PERFORMANCE *IQ*'S, OBTAINED BY SUBTRACTING PERFORMANCE *IQ* FROM BINET *IQ*, IN 32 CASES OF BIRTH INJURY (DATA PROVIDED BY WERNER): MINUS SIGNS INDICATE THAT THE PERFORMANCE *IQ* IS HIGHER [1]

Difference	No. of cases	Difference	No. of cases
24 to 20	1	− 1 to − 5	2
19 to 15	0	− 6 to −10	7
14 to 10	1	−11 to −15	9
9 to 5	3	−16 to −20	1
4 to 0	5	−21 to −25	3

[1] Range of Binet *IQ*'s, from 50 to 99: of performance *IQ*'s, 53 to 105.

Table II summarizes the differences between Binet and performance *IQ*'s. These show, as others have observed, that the non-verbal *IQ* of the birth-injured tends to be higher than his verbal *IQ*. There is, however, no indication of a bi-modal distribution of differences. They range from plus 23 to minus 25; disregarding sign, from 0 to 25, with a median difference of 10 points in *IQ*. Arthur (1933, table XXV) gives median differences for normal children from 5.5 to 14.0; for children of the same range of *IQ* as those of the present group, a median difference of about 7.5. The *median* difference therefore is somewhat greater than normal, but the individual differences are within the normal range (see Arthur's table XXXIV, for example, for normal Italian and Jewish children, where the differences range from plus 23 to minus 36 for children whose Binet *IQ*'s are below 100).

Obviously vocabulary is markedly depressed in these cases, and has not the relationship to other scores that is apt to be found in cases of adult deterioration. There is no evidence of a bi-modal vocabulary distribution, nor of a bi-modal distribution of the relationship between verbal and non-verbal ability. The low level of vocabulary score means that the "non-aphasic syndrome" of the adult is not to be found here.

Nor does the adult aphasic syndrome appear. "Speech-area" injury in the infant may affect later symbolic formulation and expression: indeed, it is possible that the more extreme defects of imbecility or idiocy (not represented in the group analyzed) may be the result of injury to what, in the adult, is the speech area. But it is characteristic of aphasics to have some non-verbal abilities well within the normal range, with the verbal abilities outside the normal range: in a large proportion, with a marked discrepancy between verbal and non-verbal abilities. No writer has discussed, as far as I am aware, the occurrence of aphasia as the result of birth injury (as distinct from lesions occurring or progressing after speech has developed), but it appears that when verbal defects are as serious as those of aphasia the level of other abilities is not far removed. In short, the only children whose verbal capacities are as poor as in the ordinary case of aphasia would be imbeciles at least. Doll (1933) refers to the effect of birth injury upon speech, pointing out that speech defects may be accompanied by normal ability elsewhere, but he appears to mean a kind of defect which is not at all like the aphasic disturbance of symbolic function. Such defects are to be thought of as disturbances of speech production, not of the cortical processes underlying speech organization (just as there are adult speech disturbances which have no relation to aphasia).

It is well to make the point that the vocabulary ability of the birth-injured child is not depressed merely by a lack of opportunity or of normal experience. In three of the cases observed at the Montreal Neurological Institute information on this point was obtained.

The first (J. B.) was a young woman of 19 years of age, suffering from hydrocephalus which dated apparently from the age of 5 years. The patient made a score of 6 on the revised Stanford-Binet list (level of Year VI; *M.A.* 6–10; basal age VI, highest success at VIII). She attended school until the age of 13, and apparently lived a normal life at home until the time of entering hospital. The second (L. S.) was a girl aged 13 years, 1 month, with a history of birth injury and convulsions. She attended school, but did not learn to read or write; her mother, however, said that she helped with the housework at home. In

spite of this, she did not know what "eyelash" meant, nor "scorch"; "muzzle" she said was "muslin cloth". Vocabulary score 8 (Year VIII; *M.A.* 5–7; basal age IV–6, highest success at VIII). The third case (N. H.) is clearest of all; a girl aged 12 years, 2 months, with epilepsy following birth injury. The mother apparently devoted all her time to trying to teach the child and to train her as other children. She had been taught to sound simple words phonetically, and with a familiar book seemed to be able to read, although in fact she could only repeat the story by memory. She talked fluently, and no effort had been spared to bring her up normally. The vocabulary score was 7 (Year VII approximately; *M.A.* 6–8; basal age VI, highest score at VIII). If opportunity determined size of vocabulary, it would have led to a higher score in this case.

Finally, a case reported by Bradway (1937) will be cited. It has a special importance in that the birth-injured child had an identical twin (case of Jim and Burton). There was no sensory or motor handicap, and the two boys grew up together and enjoyed being mistaken for one another. At the age of 13–2, one twin had a Stanford-Binet *M.A.* of 13–1 (*IQ* 98), the other of 6–7 (*IQ* 51). Vocabulary scores, with one list, were 28 and 12 respectively. This is exceptionally direct evidence of the effect of an early cerebral injury, with both environment and original potentiality controlled.

Validity of the Comparison between Early and Late Injury

The psychometric data from these cases of exogenous mental defect make it appear that vocabulary, and other abilities tested by the Stanford-Binet, are depressed by birth injury. There is very nearly conclusive evidence that vocabulary and some of these other verbal abilities are not seriously affected by injury occurring at maturity, except in the case of aphasia; and aphasia itself is characterized, in a fairly large number of cases, by the rather high level of some non-verbal abilities, which again does not appear true of mental deficiency. Unless there is what Kennedy and Wolf consider to be a combination of aphasic and non-aphasic deterioration, adult brain injury is likely to leave some abilities at a nearly normal level. How valid is this comparison of test scores in cases of early and late injury?

The low vocabulary scores after early brain injury have been shown not to be due to environmental deficiencies. Another possible explanation can also be ruled out; that the lesions of infancy may be more widespread or more diffuse, involving possibly more dysfunction of the partly destroyed tissue, and that they are more deteriorating for this reason. From the evidence of Rowe's case of hemidecortication, and that of Case 1, as well as from the data of Weisenburg and McBride from their non-aphasic control group (essentially a group of cases of diffuse injury), it seems that diffuse destruction to the adult brain, like the clean-cut surgical removal, leaves certain verbal abilities at most only slightly disturbed. It is important to note that this is true even when other abilities are seriously disturbed indeed, as in Case 2: here surely the lesion was capable of affecting intellect—without greatly affecting vocabulary and some kinds of problem-solving. So in aphasia; some abilities are depressed to a degree that, with infant injury, is only found in extreme cases of mental deficiency. The conclusion drawn from the comparison is not that intellect is less disturbed by adult injury, but only that some things are less disturbed and that the defects resulting from early and late injury are qualitatively different. It may be—in fact, it seems likely—that in other abilities the effect of early injury is less than that of late injury.[3]

The real difficulty in making this comparison is the possibility of an unsuspected degree of selection in the birth-injury population studied.

If the effect of early and late injury is the same, the only way of accounting for low vocabulary scores in the birth-injured is by supposing that the known population have speech-area damage. This might happen in either of two ways: either the early injury tends to be bilateral, or only children with speech area damage are sufficiently retarded to be detected as clinical cases (since we are dealing with cases in which there are no gross motor or sensory disabilities). Since it is known that there is more restitution of function with infant than with adult injury to the brain, verbal abilities would tend to be low, but not as low as in adult aphasia. Such possibilities cannot be entirely dismissed, for the exact determination of site and

[3] It would be easy to over-simplify the distinction between cases of early and late injury. Werner's qualitative analysis of exogenous mental defect has shown the existence of a kind of dis-organization which is strikingly similar in some respects to what may be found with certain kinds of adult injury. The contrast drawn here is between patterns of test scores only.

extent of injury with early lesions is a very difficult business, as Doll (1933) has pointed out.

It seems most unlikely that every detected case of infant injury, without gross motor defect, involves speech area damage, although this must remain, at present, as a possibility. Animal studies have consistently indicated that early damage is less deteriorating than late damage (*e.g.* Lashley, 1933; 1938; Tsang, 1937; Beach, 1938), and there is no experimental support for an opposed conclusion based on clinical evidence. It may be pointed out, however, that indices of animal intelligence have never been comparable to those of the standard intelligence test, which is concerned mainly with complex abilities developed during the whole period of growth rather than with the rate of acquisition of a new skill at maturity. Finally, it should be repeated once more that the tentative conclusion drawn from these clinical comparisons is that only a few abilities (of the many rated by standardized tests) seem to be retained better after late than after early injury to the human brain.

The Development and Retention of Intelligence

The weight of evidence points to a more widespread and less selective effect of the large infant injury than of the large adult injury. Unless known cases of exogenous mental defect involve lesions in the speech areas (the possibility already discussed), to account for the uniformly low vocabulary and verbal test scores, it must be that *low verbal test scores are produced by early lesions outside the speech areas.* With vocabulary at least it appears that a cerebral lesion may be deleterious at infancy and not at maturity, for such lesions at maturity do not affect vocabulary to a detectable degree. If this is so, the development and the retention of an ability may depend on the brain in different ways. An intact cerebrum is necessary for the normal development of certain test abilities, but not for their retention at a nearly normal level. In other words, *more cerebral efficiency or more intellectual power is needed for intellectual development than for later functioning at the same level.*

Stating the problem in this way suggests a clue to a possible solution. The actual modifications of behavior which occur in intellectual development are mostly qualitative. Faced with a complex situation, the subject sees it in a new way and makes a new response—not more responses or harder responses. Now often in such modifications of behavior it is the first steps which demand intellectual capacity. Learning to solve a problem demands more intellectual effort than solving more problems of the same kind; this is obvious with formal problems, but it may also be true of the perception of relationships: in the figures used by the Gestalt psychologists, in puzzle pictures of the kind made to amuse children, in Street's Gestalt Completion test, there is ample evidence that the original perception of a relationship may make more intellectual demand than the same perception later. It is not far-fetched to suppose that this is also true of the perception of relationships in everyday events which the growing child does not set out consciously to master, as he must an arithmetic problem or a puzzle picture, but which make up the "problems" of everyday life. The intelligent child solves these problems without thinking of them as such, but nevertheless at a faster rate than the less intelligent: intellectual capacity must be important in the development and it is plausible to suppose that here, as in more formal intellectual undertakings, the first achievement is what requires the greater amount of intellect. The development of social appreciation, common sense and verbal comprehension, therefore, may demand an intact brain, while their retention does not.

Intellectual development then would involve stable, qualitative changes of behavior and perception, dependent for their first appearance upon more elaborate intellectual processes than for their later functioning. Physiologically, this implies that stable changes of neural organization may occur as the result of activity in other parts of the nervous system. Normal development of verbal comprehension demands an intact or almost intact cerebrum, but its persistence at a high level is possible after the removal of the right half of the cerebral cortex. This is accounted for on the supposition that the actual basis of the adult verbal response is in the middle regions of the left hemisphere (in right-handed individuals, of course), but that the physiological organization of this part of the brain is partly determined by earlier activities in the rest of the brain. The qualitatively good response is a modification due to an earlier and more elaborate kind of cerebral activity.

All this, however, emphasizes only one of the factors entering into test performance—the one accounting for high scores following mature brain injury. But verbal test indices, like non-verbal, vary in their susceptibility to the effect of injury outside the speech areas and no test is wholly un-

affected. The stable qualitative changes of intellectual development are therefore not all that is rated by intelligence tests. To a varying degree, the tests must also measure something closer to the intellectual power that produced the qualitative changes in the first place.

An hypothesis can now be stated, to account for the high level of certain test scores following late brain injury, for the varying degree to which other test scores are affected, and for the differences of the effect of early and late injury:

In any test performance there are two factors involved, the relative importance of which varies with the test: one factor being present intellectual power, of the kind essential to normal intellectual development; the other being the lasting changes of perceptual organization and behavior induced by the first factor during the period of development. Roughly, the one concerns power of "reasoning", of synthesis and invention; the other skill (that is, a factor due to experience). The term "present intellectual power" is not altogether satisfactory; it is used in a special sense not equal to "present intellectual efficiency", since efficiency would be determined by both factors, not only one. The clinical data indicate that both are of essential importance in intelligence as it would be identified either by tests or by common sense. The contrast is not between intelligence and knowledge, but between capacity to develop new patterns of response and the functioning of those already developed.

Intellectual power might be defined as capacity to develop a test ability in the absence of any previous relevant experience. If a cortical lesion outside the speech areas prevents the acquisition of a normal vocabulary in the developmental period, it should also prevent the same acquisition at maturity, provided the intellectual difficulty at maturity were the same: that is, in a hypothetical individual who had to learn not only the words but also their conceptual basis, the object- and quality-differentiations and complex habit formations common to speech in general. There must be common factors ("identical elements") and transfer of training from one language to another. An individual who had learned one language before receiving a brain injury might learn another more readily than he would have learned it *de novo* after birth injury, although not as well as a normal individual. Without "previous relevant experience" the adult should do no better than the birth-injured, from the assumption that his brain has suffered as much physiological disruption as the child's. Power to *develop* the ability is therefore diminished by the mature injury, so there is some loss of intellectual power. The level at which the ability, once developed, is retained is not an index of the individual's hypothetical power to develop the ability from scratch: the actual verbal performance is determined not only by this power, but also by the degree of verbal development before the occurrence of the injury.

During development test abilities correlate rather well, justifying the working concept of a general level of ability. In normal growth any test score is an index of this general level. From the age of 20 onward, and after brain injury or schizophrenia, this is less true. Vocabulary is now more nearly an index of a former general level, achieved during development, than of present intellectual power in the sense defined. In this sense, and with the assumptions that have been made, the more sensitive test indices are the better clues to present intellectual power.

But it should also be remembered that many of the abilities needed in ordinary adult life are like vocabulary, a retained level of functioning. For these, the less sensitive indices such as vocabulary will predict level of functioning best, or the Stanford-Binet better than a performance test.

The hypothesis has a bearing on another matter, the development of abilities after birth injury, particularly in those cases which involve a variable degree of dysfunction (revealed by the E.E.G. or by fluctuation of clinical symptoms). Without going into the inferences in detail, these deductions logically follow:

(1) Early lesions will tend to produce low scores in both Binet and performance-test tasks, regarding the Binet as predominantly a level-of-development index, the performance test predominantly as a present-level index.

(2) If the depression of test scores is due to dysfunction more than to the permanent destruction of tissue, reversal or termination of dysfunction will permit a more rapid rise of the performance-test scores, but only a very slow rise of Binet scores. This would be true also when dysfunction is of decreasing severity; in either case one would expect higher performance-test scores than Binet or vocabulary scores. These level-of-development indices would be more stable and less responsive to changes of intellectual efficiency.

(3) When the lesion occurs in the middle of the developmental period, or when dysfunction occurs then or is of increasing severity during growth (as when epilepsy appears late or is becoming worse), the test score pattern would tend to approach that

found in adult deterioration, with Binet and vocabulary indices relatively high.

(4) With sporadic dysfunction (as for example in the variable deterioration of behavior that may be associated with abnormal E. E. G. records), the patient in "good" periods would be better at performance tasks, in bad periods better at Binet tasks.

The hypothesis is based on what appears to be a characteristic difference in the effect of early and late brain injury; but the corollaries of the hypothesis show that the difference need not always be clear-cut. In some cases the effect of early injury might approach that of late injury, and there might be a wide variation of test-score pattern from one case to another. The hypothesis assumes only that certain test scores are less sensitive to adult than to infant injury, and that on the whole there is less disparity in the effect of infant injury on different test scores.

Vocabulary, unspeeded verbal comprehension and so on may be regarded as primarily indices of a level of past development, while some other tests, more sensitive to the effect of injury to the mature brain, are better indices of "present intellectual power"; keeping in mind, however, the implication of the hypothesis presented—that adult intellectual efficiency in many matters is determined more by the highest past level of intellectual power than by the level of "present intellectual power". There are, in this view, two ways in which a test may function.

Weisenburg and McBride (p. 329) have made a somewhat similar distinction of test material, related to the familiarity or unfamiliarity of the task. Finding no evidence of loss, after right-sided cerebral destruction, in tests of sentence dictation, oral spelling, and vocabulary, they say:

> It is noteworthy that these are language tests involving the reproduction of acquired knowledge in situations not unfamiliar to everyday experience. They [the patients] fall furthest below the normal on the Sentence Completion Test, which involves constructive synthetic mental activity in a situation which is not difficult for them to grasp, but still a less natural situation.

Emphasis here should be put on the kind and form of task rather than on "reproduction of acquired knowledge", if this phrase means the reproduction of material in the form in which it was learned. It must be insisted that in an oral vocabulary test the subject is not asked to repeat a form of words as he learned them, and a high score cannot be explained as due to rote memory. In spelling, this is often true; the child in school learns to repeat individual letters in the proper order; when he is tested as an adult he may make the same response from memory. Vocabulary tests are another matter. Common words are rarely learned by their definitions; still less are the definitions learned by heart. It is their use that is learned. The evidence in Rowe's case, and in Cases 1 and 2 of this paper, shows that comprehension and memory for complex verbal material heard *for the first time* are also insensitive to late injury. The kind of task is familiar; the specific content, and the actual response to be made, are not.

There is a still more cogent reason for not dismissing the vocabulary score of the adult brain-injured as a mere feat of memory. This is the correlation between vocabulary score and post-operative social competence, conversational ability (ability, that is, to understand and communicate ideas) and general level of functioning in ordinary life. I must revert here to the frequency with which relatives or friends, as well as the attending clinicians, report of the patient who has had successful removal of a large amount of cerebral tissue that his intelligence is unimpaired, and the inescapable conclusion that the patient has retained some essential and important part of his intellectual powers. Vocabulary score therefore would be a better index of level of functioning in such matters than test scores which are more sensitive to the effect of brain damage.

Intellectual Changes with Age

The same thing holds true of the intellectual changes of senescence, and it is this that Jones and Conrad (1933) appear to have overlooked in concluding that vocabulary and information scores should not be used in a rating of adult intelligence, on the ground that these scores show no decline with age. As an inference from changes of test-score pattern with age, the distinction they draw is the same that is drawn in this paper: that is, between tests which are more and less susceptible to the effect of injury or atrophy of the brain. But their theoretical interpretation of the facts does not stand closer analysis, nor does the conclusion that some tests measure "basic intelligence", others "acquired abilities". No hard-and-fast line can be drawn between two types of test.

Jones and Conrad conclude that Army Alpha subtests 4 and 8, vocabulary and information, are acquired abilities; and by implication that others are not. No exception need be taken to this if

it meant only that skills developed with experience were more important in some test abilities, or that other tests are more closely related to the physiological status of the cerebrum as it becomes impaired with age. But it is not clear how one can say that vocabulary is an acquired ability while arithmetic or common sense (Test 3) is not. The view is taken that older adults have an unfair advantage with tests of vocabulary and information because they have had a longer time to acquire these things, and that the younger adult has not "enjoyed equal familiarity with the experience variables affecting test score" (p. 249). This argument might have been applied with equal force to other tests. It is not valid if a limited period teaches the subject all he is capable of learning—if inherent capacity, that is, sets a limit to the level attainable. The correlation between information and other tests of intelligence means that the range of knowledge is determined by intellectual capacity as well as by time of exposure to the facts. Deficient experience can certainly lower vocabulary or information scores, but it does not appear that over-experience can greatly raise them in the absence of special motivation. Given a reasonable degree of exposure, score is not a function of amount of further exposure.

In condemning these tests of "acquired information", Jones and Conrad neglect the fact that they may be the best indices, even in senescence, of an important part of intellectual function. Net intellectual efficiency as it is actually manifested certainly does not begin to decline in adolescence, but appears in many occupations to gain steadily up to thirty or forty, and to be well maintained for some time later. The efficiency is not only due to a greater collection of facts, but is manifested often in creative work or in meeting new situations. The manager of a grocery store or bank, the politician, the novelist, the artist, the boat builder and inventor are by no means always most capable in their twenties. If genius often shows up early, it has shown up late as well. Granted that there is an early decline of what Thorndike calls "sheer modifiability" (Thorndike *et al.*, 1928), there is an increase of something else which often more than balances the loss.

The significance of the tests of "acquired information" is greater if they are really indices of important components of adult intelligence. Wechsler (1939, p. 59), who agrees with Jones and Conrad, but not to the extent of rejecting information and vocabulary as tests of intelligence, ascribes continued efficiency in senescence to an increased store of "acquired knowledge". This must be denied. It would be easy to show—tests of information do show it—that older men do not so excel younger men in range of knowledge that a serious loss of intelligence could be hidden. Wechsler's "old clinician" would have a harder time passing factual examinations than the younger one, and still, as Wechsler says, the older man may be the better doctor. If he is, it must be because he is better at solving the problems of medical practice—even if he is not better at solving text-book problems. To rate the intelligence of older men, tests should be used in which they do relatively well, as well as ones in which they do relatively badly.

The implication of the hypothesis presented here is that the formation of the qualitative modifications of behavior may continue for some time after intellectual power has reached its peak, and that when tests of more genuinely adult interest are developed they may be found, unlike "power" tests but like vocabulary and some other tests (Conrad, 1930) to continue to show a rise for some time after the onset of puberty. The functioning of intelligence in practice demands that these subjective products of earlier intellectual activity be available, that the understanding of common situations and the solution of routine problems occur without intellectual effort. The farther this process has gone, the more efficient intelligence will be. No amount of native mathematical aptitude, even to the extent of genius, will make original contributions to higher mathematics possible until the ideas of elementary algebra and geometry are second nature, so that real intellectual effort is saved for the advanced problem. Intellectual development, therefore, involves (*A*) the development of direct intellectual power, by neural maturation, and (*B*) the establishment of routine modes of response to common problems, or of perceptual and conceptual modifications leading to qualitative modifications of behavior.

The kind of test ability which is generally thought to reach its peak earliest, perhaps between the ages of 12 to 15 years, is the kind which is also more apt to be sensitive to the effect of brain injury after this period, and sensitive as well to the changes of senescence. Direct intellectual power, therefore, may be thought to be at a maximum before the age of 16 years. What we call intelligence, however, would involve both (*A*) and

(*B*). It would therefore continue to rise to the point at which declining intellectual power offset the increase of intellectual products. For some problems, this peak of efficiency would be reached early; for others late, depending on the extent to which subsidiary problems are involved in the solution of the more difficult problems. Pure puzzle-solving might reach its peak early, for each puzzle would be more or less isolated; but insight into social relationships or skill at dealing with other people might reach a peak very much later and then be maintained.[4] It is granted at once that this high level of problem solving by older subjects is likely to be within a strictly limited range, but this does not justify the psychological conclusion that intelligence begins to decline with adolescence, nor the idea that the older subject gives only an appearance of intelligence. He may not function as well in a wide range of tasks, and may not maintain as high a level of efficiency over long periods; but in all that kind of comprehension which is commonly thought of as demanding maturity of judgment it is likely that the older man has as high a level of functioning as the younger man, if not in many matters a higher one. We have as yet no good measures of "the integrative mental processes interpretative of [adult] experience" (Miles, 1933), but when these processes can be measured one may expect to see a more adequate picture of psychological maturity.

Theory of Cerebral Function

If intellectual development in man is of this kind, there are new complications in a field which was complicated enough already: the study of the relationship of intelligence to the human brain.

Recently Lashley (1938) has fundamentally reoriented the problem by presenting evidence of independent and qualitatively distinct processes making up mammalian intelligence. Discarding a former concept of general intelligence as a single quantitative variable related to total cortical mass, Lashley now takes the position that major differences of intelligence involve qualitative differences in the kind of abstraction possible. Cortical mass is unimportant for some abilities; it is most important for others. For some capacities of the animal the whole cortex may be equipotential, while others may be dependent on a restricted cortical zone. In the analysis of cerebral function the question becomes: what abilities are localized, and for what abilities must we take into account mass action and equipotentiality of function? Fundamental to this is the difficulty of analyzing human behavior, of isolating the qualitatively distinct functions postulated by Lashley, and it is this difficulty that is made worse by the hypothesis of the present paper.

The clinical evidence reviewed here has been quite in accord with Lashley's position. The apparently generalized effect of infant lesions argues for some degree of equipotentiality of the cortex in development. Even verbal abilities, which seem so sharply localized in the speech areas of the adult, have been seen to be dependent on the integrity of the whole cerebrum for their normal development. The peculiarities and selectivity of the effect of late injury make it clear that the functions comprising normal intelligence must be in some sense independent of one another. It is impossible to predict from deterioration in one ability what others will be involved with it. Attention has been drawn to the anomalous finding of Rylander that differentiation of abstract words is affected by lesions that do not affect total vocabulary. A report has also been given elsewhere (Hebb, 1939) of a case in which a right temporal lobe lesion led to non-verbal behavior like that often found in aphasia, and with apparent disturbances of social comprehension, but without evidence of loss in verbal abilities. These are rather restricted defects which can hardly be arranged in a quantitative series. It was said in discussing Case 2 that such defects cannot be described as the loss of a single intellectual function, and that one ability is never completely lost without others' being affected; but this of course may be due only to the use of tests which measure a mélange of functions in varying degree.

It would be most desirable to relate the results of clinical analysis to the pioneering work of Thurstone[5] (1938, 1940) in the qualitative analysis of "general intelligence" by quantitative methods. The clinical analysis certainly gains support

[4] And the report by Gilbert (1935) that age has less effect on brighter subjects suggests that net efficiency may rise for a longer period if the original level was high.

[5] Cattell (1942) in an independent approach to the problem has shown that Spearman's "g" can also be related to this type of analysis. Cattell's theory was developed in part on the basis of the present discussion, but his treatment concerns a wider range of facts and significantly adds to the theory by showing among other things that it makes the "g" hypothesis (with some modification) fit facts from the normal adult and clinical fields which would otherwise appear incompatible with "g".

from his success with the method of simple structure. The re-appearance of the same primary factors in several experiments, with different test batteries and different populations, offers some guarantee that these factors are more than mathematical artefacts. But the variables so found could not be independently measured, even if one attempted to construct tests specially for the purpose; clinical tests are of course even more impure, and it cannot be expected that the loss of a single intellectual function would be detected as loss in a single test ability. This is essentially the reason that there is little evident relation between the results of factor analysis and the crude clinical analysis of test score patterns in deterioration, except in Thurstone's suggestion that amnesic aphasia may be regarded as loss in factor *W*, or "word fluency".

The general significance of Thurstone's results is the same as that of the clinical evidence which points rather obscurely to the functional independence of some of the factors making up human intelligence. On the other hand, the contrast drawn here between the effect of early and late injury to the brain raises the question of how far the clinical suggestion of independent factors may be due to the varying degree to which adult test abilitites are related to "present intellectual power" (as the term has been defined). Thurstone and Lashley have raised as a primary problem the question of isolating qualitatively distinct factors in intelligence; the hypothesis presented here adds the problem of distinguishing the direct expression of intellectual power from its effects during growth.

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SUMERIAN LITERATURE; A PRELIMINARY SURVEY OF THE OLDEST LITERATURE IN THE WORLD

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LIST OF ABBREVIATIONS

AOF	*Archiv fur Orientforschung* (Berlin).
AS No. 12	Kramer, Samuel N. *Lamentation over the Destruction of Ur* (Chicago, 1940).
BASOR	*Bulletin of the American Schools of Oriental Research* (Baltimore).
BE XXXI	Langdon, S. H. *Historical and Religious Texts from the Temple Library of Nippur* (München, 1914).
CBS	Catalogue of the Babylonian Section of the University Museum (followed by number).
GSG	Poebel, Arno. *Grundzüge der Sumerischen Grammatik* (Rostok, 1923).
HGT	Poebel, Arno. *Historical and Grammatical Texts* (Philadelphia, 1914).
JAOS	*American Oriental Society, Journal* (Boston).
K	British Museum. Kouyunjik collection (followed by number).
Ni	Museum of the Ancient Orient (Istanbul). Nippur Collection.
PBS I 1	Myhrman, David W. *Babylonian Hymns and Prayers* (Philadelphia, 1911).
PBS X 2	Langdon, S. H. *Sumerian Liturgical Texts* (Philadelphia, 1917).
RA	*Revue D'Assyriologie et D'Archéologie Orientale* (Paris).
SBH	Reisner, George A. *Sumerisch-babylonische Hymnen nach Thontafeln griechischer Zeit* (Berlin, 1896).
SEM	Chiera Edward. *Sumerian Epics and Myths* (Chicago, 1934).
SRT	Chiera, Edward. *Sumerian Religious Texts* (Upland, Pa., 1924).
ŠL	Deimel Anton. *Šumerisches Lexicon* (Rome, 1930).
TRS	Genouillac, Henri de. Textes Religieux Sumériens du Louvre (Paris, 1930).
VS II	Zimmern, Heinrich. *Sumerische Kultlieder aus altbabylonischer Zeit*, 1. Reihe (1912).
VS X	Zimmern, Heinrich. *Sumerische Kultlieder aus altbabylonischer Zeit*, 2. Reihe (1913).
ZA	*Zeitschrift fur Assyriologie und verwandte Gebiete* (Leipzig).

THE SIGNIFICANCE OF SUMERIAN LITERATURE

THE Sumerians are a non-Semitic people who flourished in southern Babylonia from the beginning of the fourth to the end of the third millennium B.C. During this long stretch of time, the Sumerians, whose racial and linguistic affiliations are still unclassifiable, represented the dominant cultural group of the entire Near East. This cultural dominance manifested itself in three directions:

1. It was the Sumerians who developed and probably invented the cuneiform system of

writing[1] which was adopted by nearly all the peoples of the Near East and without which the cultural progress of western Asia would have been largely impossible.

2. The Sumerians developed religious and spiritual concepts together with a remarkably well integrated pantheon which influenced profoundly all the peoples of the Near East including the Hebrews and Greeks. Moreover, by way of Judaism, Christianity, and Mohammedanism, not a few of these spiritual and religious concepts have permeated the modern civilized world.

3. The Sumerians produced a vast and highly developed literature, largely poetic in character, consisting of epics and myths, hymns and lamentations, proverbs and "words of wisdom." These compositions are inscribed largely in cuneiform script on clay tablets and fragments dated approximately 2000 B.C. In the course of the past hundred years, approximately three thousand such literary pieces have been excavated in the mounds of ancient Sumer. Of this number, *over two thousand*, more than two-thirds of our source material, were excavated by the University of Pennsylvania in the mound covering ancient Nippur in the course of four gruelling campaigns lasting from 1889 to 1900; these Nippur tablets and fragments, therefore, represent the major source for the reconstruction of the Sumerian compositions. As literary products, these Sumerian compositions rank among the finest creations known to civilized man. Their significance for a proper appraisal of the cultural and spiritual development of the Near East can hardly be overestimated. The Assyrians and Babylonians took them over almost in toto. The Hittites translated them into their own language and no doubt imitated them widely. The form and contents of the Hebrew literary creations and to a certain extent even those of the ancient Greeks, were profoundly influenced by them. As practically *the oldest written literature of any significant amount ever uncovered*, it furnishes new, rich, and unexpected source material to the archaeologist and anthropologist, to the ethnologist and student of folk lore, to the students of the history of religion and of the history of literature.

In spite of their unique and extraordinary significance, and although the large majority of the tablets on which they are inscribed have been excavated almost half a century ago, the translation and interpretation of the Sumerian literary compositions have made relatively little progress to date. The translation of Sumerian is a highly complicated process. The grammar has only comparatively recently been scientifically established, while the lexical problems are still numerous and far from resolved. By far the major obstacle to a trustworthy reconstruction and translation of the compositions, however, is the fact that the greater part of the tablets and fragments on which they are inscribed, and which are now largely located in the Museum of the Ancient Orient at Istanbul and in the University Museum at Philadelphia, have been lying about uncopied and unpublished, and thus unavailable for study. To remedy this situation, I travelled to Istanbul in 1937, and with the aid of a Guggenheim fellowship, devoted some twenty months to the copying of one hundred and seventy tablets and fragments in the Nippur collection of the Museum of the Ancient Orient. And largely with the help of a grant from the American Philosophical Society, the better part of the past two years has been devoted to the studying and copying of the unpublished literary pieces in the Nippur collection of the University Museum. As a consequence we are now already in a position to reconstruct the greater part of the texts of twenty-three unique and significant Sumerian epics and myths and are at last on the very threshold of apprehending their contents.[2] The completion of the final translation of the epics and myths will be followed by the reconstruction of the contents of the important collection of Sumerian hymns dedicated to their gods and kings. I then hope to concentrate all my time and efforts to the Sumerian lamentations and to their proverbs and wisdom literature; this latter group is particularly difficult to decipher because of the laconic and cryptic wording of their contents. Finally as a crowning achievement it is hoped to reconstruct and translate the Sumerian Tammuz compositions, the forerunners of the ancient myths concerned with the dying god and his resurrection, a group of compositions which are of basic significance for a scientific approach to the history of religion.

[1] For a sketch of the fascinating story of the decipherment of Sumerian, as well as a brief general appraisal of the contents of the Sumerian tablets excavated in the course of the past century, *cf.* Excursus A: *The Decipherment of Sumerian.*

[2] For an outline of the contents of these twenty-three compositions, *cf.* Excursus B: *Sumerian Epics and Myths.*

As an illustration of the temper and mood, the swing and rythm of Sumerian poetry, may I present to the American Philosophical Society the translation of a myth whose text has been reconstructed and deciphered by me in the course of the past several years. Creatively speaking, it undoubtedly ranks among the great compositions of all times. Its influence on literature has been universal and profound. Moreover the story of its decipherment will furnish an illuminating illustration of the not uninteresting process involved in the reconstruction of a Sumerian literary composition.

Inanna's Descent to the Nether World

Introduction

For many many years, for almost three quarters of a century, a myth usually designated as *Ishtar's Descent to the Nether World* has been known to scholar and layman. Because it is written in Assyrian, a Semitic language, on tablets dating from the first millennium B.C., tablets, therefore, that are later by more than a millennium than our Sumerian literary pieces, it was generally assumed to be of Semitic origin. It is therefore quoted and sited in all major works concerned with mythology and religion as a remarkable example of Semitic myth-making. With the appearance of the publications of the Nippur literary material, however, it gradually became obvious that this "Semitic" myth goes back to a Sumerian original in which Ishtar is replaced by Inanna, her Sumerian counterpart. Arno Poebel, now of the Oriental Institute of the University of Chicago, was the first to locate three small pieces belonging to this myth in the University Museum; these he published under the auspices of the University Museum in 1914. In the very same year, the late Stephen Langdon of Oxford, published two pieces which he had uncovered and copied in the Museum of the Ancient Orient at Istanbul. One of these was the upper half of a large four column tablet, which, as will soon become evident, proved to be of major importance for the reconstruction of our myth. The late Edward Chiera, a member of the faculty of the University of Pennsylvania until called to head the Assyrian Dictionary staff of the Oriental Institute of the University of Chicago, uncovered three additional pieces in the University Museum at Philadelphia. These were published in his two posthumous volumes of Sumerian literary texts which I prepared for publication by the Oriental Institute in 1934.

By this time, therefore, we had eight pieces, all more or less fragmentary, dealing with the myth. Nevertheless the contents remained obscure, for the breaks were so numerous and came at such crucial points that an intelligent reconstruction of the extant parts of the composition was impossible. It was a fortunate and remarkable discovery of Chiera which saved the situation. He discovered in the University Museum in Philadelphia, the *lower* half of the very same four columns tablet whose *upper* half had been found and copied by Langdon in the Museum of the Ancient Orient in Istanbul years before. The tablet had evidently been broken before or during the excavation and the two halves had become separated, the one was retained in Istanbul and the other came to Philadelphia. Unfortunately, Chiera, who fully recognized the significance of his discovery, died before he was in a position to utilize its contents.

It was by making use of this lower half of the four column tablet, despite the fact, that it, too, is very poorly preserved, that I was enabled to reconstruct the contents of the myth. For when joined to the upper part of the tablet, the combined text furnishes an excellent framework in which and about which all the other texts could be grouped. Needless to say there were still numerous gaps and breaks in the text which made the translation and interpretation of the contents no easy matter, and the meaning of several of the more significant passages remained obscure. In 1937 I was fortunate enough to discover in Istanbul three additional pieces belonging to the myth, and upon returning to the United States in 1939 I located yet another large piece in the University Museum. Quite recently in the process of reexamining the Nippur collection in the University Museum I discovered another small piece which is being published here for the first time. These five pieces helped to fill out the most serious lacunae in my first reconstruction, and as a result, the story, as far as it goes, is now practically complete. It runs as follows:

Inanna, the Queen of Heaven, the goddess of light, and love, and life has set her heart upon visiting the Nether World, perhaps in order to set free her lover Tammuz. She collects all the appropriate divine decrees, adorns herself with her queenly robes and jewels, and is ready to enter the "Land of No Return." Queen of the

Nether World is her elder sister and bitter enemy Ereshkigal, the goddess of darkness, and gloom, and death. Fearing lest her sister put her to death in the Nether World, Inanna instructs her messenger Ninshubur who is always at her beck and call, that if after three days she shall have failed to return, he is to set up a hue and cry for her in Heaven, in the assembly hall of the gods. Moreover, he is to go to Nippur (the very city where our tablets have been excavated) and plead before the great god Enlil to save Inanna from Ereshkigal's clutches. If Enlil refuses, he is to go to Ur (Ur of the Chaldees, whence, according to Biblical tradition, Abraham migrated into Palestine) and plead before Nanna, the great Sumerian moon-god, to come to her rescue. If Nanna, too, refuses, he is to go to Eridu (the city in which Sumerian civilization originated according to Babylonian tradition) and repeat his plea before Enki, the Lord of Wisdom, and the latter, who "knows the food of life," who "knows the water of life," will surely restore her to life.

Inanna then descends to the Nether World and approaches Ereshkigal's temple of lapis lazuli. At the gate she is met by the chief gatekeeper who demands to know who she is and why she has come. Inanna concocts a false excuse for her visit, and the gatekeeper, upon instructions from his mistress leads her through the seven gates of the Nether World. As she passes through each of the gates her garments and jewels are removed piece by piece in spite of her protests. Finally after entering the last gate she is brought stark naked and on bended knees before Ereshkigal and the Anunnaki, the seven dreaded judges of the Nether World. These fasten upon Inanna their "look of death" and she is turned into a corpse which is then impaled on a stake.

So pass three days and three nights. On the fourth day, Ninshubur, seeing that his mistress has not returned, proceeds to make the rounds of the gods in accordance with his instructions. As Inanna had predicted, both Enlil and Nanna refuse all help. Enki, however, devises a plan to restore her to life. He fashions the *kurgarrû* and the *kalaturru*, two sexless creatures, and he entrusts to them the "food of life" and the "water of life," with instructions to proceed to the Nether World and sprinkle this "food" and this "water" sixty times upon Inanna's impaled corpse. This they do, and Inanna revives. As she leaves the Nether World, however, to reascend to the earth, she is accompanied by the dead and by the bogeys and harpies who have their home there. Surrounded by this ghostly, ghastly crowd she wanders from city to city in Sumer.[3]

[3] Here all the extant source material for *Inanna's Descent to the Nether World* unfortunately breaks off. But this is not the end of the myth. It is not too much to hope that some day in the not too distant future, the pieces on which the conclusion of the story is inscribed will be discovered and deciphered.

Transliteration

1. [an-gal]-ta ki-gal-šè geštug-ga-ni na-an-g[ub]
2. AN an-gal-ta ki-gal-šè geštug-ga-ni na-an-g[ub]
3. ^{d}inanna an-gal-ta ki-gal-šè geštug-ga-ni na-an-g[ub]
4. nin-mu an mu-un-šub ki mu-un-šub kur-ra ba-e-a-e$_{11}$
5. ^{d}inanna an mu-un-šub ki mu-un-šub kur-ra ba-e-a-e$_{11}$
6. nam-en mu-un-šub nam-nin mu-un-šub kur-ra ba-e-a-e$_{11}$
7. unug^{ki}-ga é-an-na mu-un-šub kur-ra ba-e-a-e$_{11}$
8. bàd-tibira^{ki}-a é-mùš-kalam-ma mu-un-šub kur-ra ba-e-a-e$_{11}$
9. zabalam^{ki}-a gi-gu$_{15}^{ki}$-na mu-un-šub kur-ra ba-e-a-e$_{11}$
10. adaba^{ki} é-šar-ra mu-un-šub kur-ra ba-e-a-e$_{11}$
11. nibru^{ki}-a bara-tuš-gar-ra mu-un-šub kur-ra ba-e-a-e$_{11}$
12. kiši^{ki}-a ḫur-sag-kalam-ma mu-un-šub kur-ra ba-e-a-e$_{11}$
13. a-ga-dè^{ki} é-ul-maš^{ki} mu-un-šub kur-ra ba-e-a-e$_{11}$
14. me-imin-bi zag mu-ni-in-kešd
15. me mu-un-kin-kin šu-ni-šè mu-un-gál
16. me-DU gìr-gub-ba i-im-DU
17. ^{tùg}šu-gur-ra-men-edin-na sag-gá-na mu-un-gál
18. ḫi-li sag-ki-na šu ba-ni-in-ti
19. gi-diš-ninda-ŠÈ-gán-za-gìn šu mi-ni-in-du$_{8}$

20. ^{na_4}za-gìn-tu$_{19}$-tu$_{19}$-lá gú-na ba-an-lá
21. ^{na_4}nunuz-tab-ba gaba-na [ba-ni]-in-si
22. ĦUR-guškin šu-na ba-ni-in-du$_8$
23. tu-di-tum-lú-gá-nu-gá-nu gaba-na ba-an-BU
24. ^{túg}palà-a-^{túg}palà-a bar-ra-na ba-an-dul
25. šim(?)-e-ḫé-im-DU-ḫé-im-DU igi-na ba-ni-in-gar
26. ^{d}inanna kur-šè i-im-du
27. sukkal-a-ni ^{d}ga-ša-an-šubur-ra[zag(?)]-a-na i-im-du
28. kug-^{d}inanna-ke$_4$ ^{d}ga-ša-an-šubur-ra gù mu-na-dé-e
29. gi-en-gi-en-mu
30. sukkal-e-ne-èm-šag$_5$-šag$_5$-ga-mu
31. ra-gaba-e-ne-èm-gi-en-gi-en-na-mu
32. u$_4$-da kur-šè mu-un-e$_{11}$-dè
33. u$_4$-da kur-šè DU-na-mu-dè
34. an du$_6$-du$_6$-dam gar-gar-ma-ni-ib
35. èš-gú-en-na tuku-a-ma-ni-ib
36. é-dingir-ri-e-ne-ke$_4$ nigin-na-ma-ni-ib
37. i-bí-zuĦUR-ma-ab ka-zuĦUR-ma-ab
38. ki(?)-mu-lu-da u-di-ṣu-gal-zu ĦUR-ma-ab
39. mu-lu-nu-tuku-gim túg-aš-a mu$_4$-ma-ab
40. é-kur-ri-é-^{d}mu-ul-líl-lá-šè me-ri-zu aš gub-mu-un
41. é-kur-ri-é^{d}mu-ul-líl-lá-šè tu-tu-da-zu-dè
42. i-bí-^{d}mu-ul-líl-lá-šè ír šéš-a
43. a-a-^{d}mu-ul-líl ṭu-mu-zu mu-lu kur-ra nam-ba-da-an-gúr-e
44. kug-šag$_5$-ga-zu saḫar-kur-ra-ka nam-ba-an-da-šár-ri
45. za-gìn-šag$_5$-ga-zu za-zadim-ma-ka nam-ba-da-an-si-il-li
46. ^{giš}urkarin(?)-zu giš-nagar-ra-ka nam-ba-da-dar-dar-ri
47. ki-sikil-^{d}ga-ša-an-na kur-ra nam-ba-da-an-gúr-e
48. u$_4$-da ^{d}mu-ul-líl e-ne-èm-ba nu-ri-gub urí^{ki}-šè DU-na
49. urí^{ki}-é-mud(?)-kalam-ma-ka
50. é-kiš-šir$_5$-gál-^{d}nanna-šè tu-tu-da-zu-dè
51. i-bí-^{d}nanna-šè ír šéš-a
52. a-a-^{d}nanna ṭu-mu-zu mu-lu-kur-ra nam-ba-da-an-gúr-e
53. kug-šag$_5$-ga-zu saḫar-kur-ra-ka nam-ba-an-da-šár-ri
54. za-gìn-šag$_5$-ga-zu za-zadim-ma-ka nam-ba-da-an-si-il-li
55. ^{giš}urkarin(?)-zu giš-nagar-ra-ka nam-ba-da-dar-dar-ri
56. ki-sikil-^{d}ga-ša-an-na kur-ra nam-ba-da-an-gúr-e
57. u$_4$-da ^{d}nanna e-ne-èm-ba nu-ri-gub uru-ṣi-ib^{ki}-šè DU-na
58. uru-ṣi-ib^{ki} é-^{d}am-an-ki-ga-šè tu-tu-da-zu-dè
59. i-bí-^{d}am-an-ki-ga-šè ír-šéš-a
60. a-a-^{d}am-an-ki ṭu-mu-zu mu-lu kur-ra nam-ba-da-an-gúr-e
61. kug-šag$_5$-ga-zu saḫar-kur-ra-ka nam-ba-an-da-šár-ri
62. ^{na_4}za-gìn-šag$_5$-ga-zu za-zadim-ma-ka nam-ba-an-da-si-il-li
63. ^{giš}urkarin(?)-zu giš-nagar-ra-ka nam-ba-da-dar-dar-ri
64. ki-sikil-^{d}ga-ša-an-na kur-ra nam-ba-da-an-gúr-e
65. a-a-^{d}am-an-ki-ù-mu-un-mu-uš-^{giš}túg-[da(?)]-ma-al-la-ke$_4$
66. ú-nam-ti-la mu-un-zu a-nam-ti-la mu-un-zu
67. e-ne ma-ra ḫu-mu-un-ti-li
68. ^{d}inanna kur-šè i-im-du
69. sukkal-a-ni-^{d}ga-ša-an-šubur-ra gù mu-na-dé-e
70. DU-na ^{d}ga-ša-an-šubur-ra
71. e-ne-a-ra dug$_4$-ga-mu-? šà la-ba-pàd
72. ^{d}inanna é-gal-kur-za-gìn-šè um-ma-te
73. ^{giš}ig-kur-ra-ka níg-ḫul ba-an-uš

74. é-gal-kur-ra-ka gù-ḫul ba-an-dé
75. é gál-ù ì-du$_8$ é gál-ù
76. é gál-ù ^{d}NE-ti é gál-ù aš-mu-šè ga-tu
77. ^{d}NE-ti-ì-du$_8$-gal-kur-ra-ke$_4$
78. kug-^{d}inanna-ra mu-un-na-ni-ib-gi$_4$-gi$_4$
79. a-ba-me-en-za-e
80. me-e-^{d}ga-ša-an-na ki-^{d}utu-è-a-aš
81. tukum-bi za-e ^{d}inanna ki-^{d}utu-e-a-aš
82. a-na-àm ba-du-un kur-nu-gi$_4$-šè
83. ḫar-ra-an-lú-du-bi nu-gi$_4$-gi$_4$-dè šà-zu a-gim túm-mu-un
84. kug-^{d}inanna-ke$_4$ mu-na-ni-ib-gi$_4$-gi$_4$
85. nín-gal-mu ^{d}ga-ša-an-ki-gal-la
86. mu dam-a-ni-ù-mu-un-gu$_4$-gal-an-na ba-an-ug$_5$-ga
87. ki-sì-ga-na i-bí du$_8$-ù-dè
88. kaš-sì-ga-na gu-ul ba-ni-in-dé hur-šè ḫé-me-a
89. ^{d}NE-ti-ì-du$_8$-gal-kur-ra-ke$_4$
90. kug-^{d}inanna-ke$_4$ mu-na-ni-ib-gi$_4$-gi$_4$
91. túm-túm-ma-ab ^{d}inanna nin-mà ga-an-na-ab-dug$_4$
92. nin-mu-^{d}ereš-ki-gal-la-ra ga-an-na-dug$_4$ ... ga-an-na-ab-dug$_4$
93. ^{d}NE-ti-ì-du$_8$-gal-kur-ra-ke$_4$
94. nin-a-ni-^{d}ereš-ki-gal-la-ra é-[a-ni-šè ba-a]n-ši-in-tu gù mu-na-dé-e
95. nin-mu ki-sikil-diš-àm
96. dingir-gim-sukud(?) .....
97. ^{giš}ig .....
98. .....
99. é-an-na-ka .....
100. me imin-bi zag mu-ni-in-kešd
101. me mu-un-kin šu-ni-šè mu-un-gál
102. me-DU gìr-gub-ba i-im-DU
103. ^{túg}šu-gur-ra-men-edin-na sag-gá-na mu-un-gál
104. ḫi-li-sag-ki-na šu ba-ni-in-ti
105. gi-diš-ninda-ŠÈ-gán-za-gìn šu mi-ni-in-du$_8$
106. ^{na4}za-gìn-tu$_{19}$-tu$_{19}$-lá gú-na ba-an-lá
107. ^{na4}nunuz-tab-ba gaba-na ba-ni-in-si
108. ḪUR-guškin šu-na ba-ni-in-du$_8$
109. tu-di-tum-lú-gá-nu-gá-nu gaba-na ba-an-BU
110. šim(?)-e-ḫé-im-DU-ḫe-im-DU igi-na ba-ni-in-gar
111. ^{túg}palà-a-^{túg}palà-a bar-ra-na ba-an-dul
112. u$_4$-ba ^{d}ereš-ki-gal-la-ke$_4$ .....
113. ^{d}NE-ti-ì-du$_8$-gal-ni-ir[mu-na-ni-ib-gi$_4$-gi$_4$]
114. gá-nu-^{d}NE-ti ì-du$_8$-[gal-kur-ra]
115. inim(?)-a(?)-ra(?)-dug$_4$(?)-ga(?)-mu geštug(?) ḫé(?)-[im(?)-ma(?)-ag(?)]
116. ká-gal-kur-ra imin-bi[^{giš}si-gar-bi gál-ù]
117. ká-gal-[ganzir-igi-kur-ra ka-aš-bi bar-ra]
118. e-ne tu-tu-da-ni-ta
119. gam-gam-ma-ni ?-?-nun-?-ni-ta .....
120. ^{d}NE-ti-ì-du$_8$-gal-kur-ra-[ke$_4$]
121. inim-nin-a-na-šè sag-kešd ba-ši-[in-ag]
122. ká-gal-kur-ra imin-bi ^{giš}si-gar-bi[in-gál]
123. ká-gal-ganzir-igi-kur-ra ka-aš-bi[in-bar]
124. kug-^{d}inanna-ra gù mu-na-dé-e
125. gá-nu ^{d}inanna tu-um-[ma-ni]

126. e-ne tu-tu-da-ni-ta
127. ^{túg}šu-gur-ra-men-edin-na-sag-gá-na lú ba-da-an-ṣi-ir
128. ta-àm-me-a
129. diri ^{d}inanna me-kur-ra-ke$_4$ šu al-du$_7$-du$_7$
130. ^{d}inanna garza-kur-ra ka-zu na-an-....-e-en
131. ká-gal-min-kam-ma tu-tu-da-ni-ta
132. gi-diš-ninda-ŠÈ-gán-za-gìn lú ba-da-an-ṣi-ir
133. ta-àm-me-a
134. diri-^{d}inanna me-kur-ra-ke$_4$ šu al-du$_7$-du$_7$
135. ^{d}inanna garza-kur-ra ka-zu na-an-....-e-en
136. ká-gal-eš-kam-ma tu-tu-da-ni-ta
137. ^{na4}za-gìn-tu$_{19}$-tu$_{19}$-lá-gú-na lú ba-da-an-ṣi-ir
138. ta-àm-me-a
139. diri-^{d}inanna me-kur-ra-ke$_4$ šu al-du$_7$-du$_7$
140. ^{d}inanna garza-kur-ra ka-zu na-an-....-e-en
141. ká-gal-limmu-kam-ma tu-tu-da-ni-ta
142. ^{na4}nunuz-tab-ba-gaba-na lú ba-da-an-ṣi-ir
143. ta-àm-me-a
144. diri-^{d}inanna me-kur-ra-ke$_4$ šu al-du$_7$-du$_7$
145. ^{d}inanna garza-kur-ra ka-zu na-an-....-e-en
146. ká-gal-ía-kam-ma tu-tu-da-ni-ta
147. ḪUR-guškin-šu-na lú ba-da-an-ṣi-ir
148. ta-àm-me-a
149. diri ^{d}inanna me-kur-ra-ke$_4$ šu al-du$_7$-du$_7$
150. ^{d}inanna garza-kur-ra ka-zu na-an-....-e-en
151. ká-gal-àš-kam-ma tu-tu-da-ni-ta
152. tu-di-tum-lú-gá-nu-gá-nu-gaba-na lú ba-da-an-ṣi-ir
153. ta-àm-me-a
154. diri ^{d}inanna me-kur-ra-ke$_4$ šu al-du$_7$-du$_7$
155. ^{d}inanna garza-kur-ra ka-zu na-an-....-e-en
156. ká-gal-imin-kam-ma tu-tu-da-ni-ta
157. ^{túg}palà-a-^{túg}palà-a-bar-ra-na lú ba-da-an-ṣi-ir
158. ta-àm-me-a
159. diri ^{d}inanna me-kur-ra-ke$_4$ šu al-du$_7$-du$_7$
160. ^{d}inanna garza-kur-ra ka-zu na-an-....-e-en
161. gam-gam-ma-ni ?-?-nun-?-ni-ta lú.....
162. [kug-^{d}ereš]-ki-gal-la-[k]e$_4$ ^{giš}gu-za-na i-ni-in-[tuš]
163. ^{d}a-nun-na-di-kud-imin-bi igi-ni-šè di mu-un-[ši-in-kud]
164. i-bí mu-ši-in-bar i-bí-úš-a-kam
165. [inim]-ma-ne-ne inim-LIPIŠ-gig-ga-àm
166. ...-tu-ra KA-..-tag(?)-tag-ga-àm
167. [munus]-tu-ra uzu-níg-sìg-šè ba-an-tu
168. uzu-níg-sìg-ga ^{giš}kak-ta lú ba-da-an-lá
169. u$_4$-eš gi$_6$-eš um-ta-zal-la-ta
170. sukkal-a-ni-^{d}nin-šubur-ra-ke$_4$
171. sukkal-inim-šag$_5$-šag$_5$-ga-ni
172. ra-gaba-inim-gi-en-gi-en-na-ni
173. an ḍu$_6$-du$_6$-dam mu-un-na-gá-gá
174. èš-ġú-en-na mu-un-na-tuku-a
175. é-dingir-ri-e-ne-ke$_4$ mu-un-na-nigin
176. i-bí-ni mu-un-na-ḪUR ka-ni mu-un-na-ḪUR
177. ki(?)-lú-da u-di-ṣu-gal-ni mu-un-na-ḪUR
178. mu-lu-nu-tuku-gim túg-aš-a[im-ma]-an-mu$_4$
179. é-kur-é-^{d}en-líl-lá-šè gìr-ni aš mu-un-gub

180. é-kur-é-^{d}en-líl-lá-šè tu-tu-da-ni-ta
181. igi-^{d}en-líl-lá-šè ír im-ma-še$_8$-še$_8$
182. a-a-^{d}mu-ul-líl ṭu-mu-zu mu-lu kur-ra nam-ba-dà-an-gúr-e
183. kug-šag$_5$-ga-zu saḫar-kur-ra-ka nam-ba-an-da-šár-ri
184. za-gìn-šag$_5$-ga-zu za-zadim-ma-ka nam-ba-da-an-si-il-li
185. ^{giš}urkarin(?)-zu giš-nagar-ra-ka nam-ba-dar-dar-ri
186. ki-sikil-^{d}ga-ša-an-na kur-ra nam-ba-da-an-gúr-e
187. a-a-^{d}en-líl-li ^{d}nin-šubur-ra mu-na-ni-ib-gi$_4$-gi$_4$
188. dumu-mu an-[gal-la] al bí-in-dug$_4$ ki-gal-la al bí-in-dug$_4$
189. ^{d}inanna an-[gal-la] al bí-in-dug$_4$ ki-gal-la al bí-in-dug$_4$
190. me-kur-ra me-al-me-al ki-bi-šè sá bí-in-dug$_4$
191. a-ba-àm ki-bi-[š]è(?)? in-na-an-dug$_4$ al mu(?)-ni-ib-dug$_4$
192. a-a-^{d}en-líl inim-ba[nu-na-gub]urí^{ki}-[šè ba]-du-un
193. urí^{ki} é-mud(?)-kur-ra-ka
194. é-kiš-šir$_5$-gál-^{d}nanna-šè tu-tu-da-ni-ta
195. igi-^{d}nanna-šè ír im-ma-še$_8$-še$_8$
196. a-a-^{d}nanna ṭu-mu-zu mu-lu kur-ra nam-ba-da-an-gúr-e
197. kug-šag$_5$-ga-zu saḫar-kur-ra-ka nam-ba-an-da-šár-ri
198. za-gìn-šag$_5$-ga-zu za-zadim-ma-ka nam-ba-da-an-si-il-li
199. ^{giš}urkarin(?)-zu giš-nam-nagar-ra-ka nam-ba-dar-dar-ri
200. ki-sikil-^{d}ga-ša-an-na kur-ra nam-ba-da-an-gúr-e
201. a-a-^{d}nanna ^{d}nin-šubur-ra mu-na-ni-ib-gi$_4$-gi$_4$
202. dumu-mu an-[gal-la] al bí-in-dug ki-gal-la al bí-in-dug$_4$
203. ^{d}inanna an-[gal-la] al bí-in-dug$_4$ ki-gal-la al bi-in-dug$_4$
204. me-kur-ra me-al-me-al ki-bi-šè sá bí-in-dug$_4$
205. a-ba-àm ki-bi-šè(?)? in-na-an-dug$_4$ al mu(?)-ni-ib-dug$_4$
206. a-a-^{d}nanna inim-ba[nu-na-gub uru-ṣi-ib^{ki}-šè ba-du-un]
207. uru-ṣi-ib^{ki} é-^{d}en-ki-ga-šè tu-tu-da-ni-ta
208. igi-^{d}en-ki-ga-šè ír im-ma-še$_8$-še$_8$
209. a-a-^{d}am-an-ki ṭu-mu-zu mu-lu kur-ra nam-ba-da-an-gúr-e
210. kug-šag$_5$-ga-zu saḫar-kur-ra-ka nam-ba-an-da-šár-ri
211. za-gìn-šag$_5$-ga-zu za-zadim-ma-ka nam-ba-da-an-si-il-li
212. ^{giš}urkarin(?)-zu giš-nagar-ra-ka nam-ba-dar-dar-ri
213. ki-sikil-^{d}ga-ša-an-na kur-ra nam-ba-da-an-gúr-e
214. a-a-^{d}en-ki ^{d}nin-šubur-ra-ke$_4$ mu-un-na-ni-ib-gi$_4$-gi$_4$
215. dumu-mu a-na bí-in-ag mà-e mu-un-kúš-ù
216. ^{d}inanna-ke$_4$ a-na bí-in-ag mà-e mu-un-kúš-ù
217. nin-kur-kur-r[a-ke$_4$]a-na bí-in-ag mà-e mu-un-kúš-ù
218. nu-u$_8$-gig-an-na-ke$_4$ a-na bí-in-ag mà-e mu-un-kúš-ù
219. ?-?-ni mu-sír ba-ra-an-túm kur-gar-ra ba-an-dím
220. ?-dirig-?-ma-na mu-sír ba-ra-an-túm ga[la-tur ba-an]-dím
221. kur-gar-ra ú-nam-ti-la ba-an-[sì(?)]
222. kala-tur-ra a-nam-ti-la ba-an-[sì(?)]
223. [a-a]-^{d}en-ki kala-tur-kur-gar-ra gù mu-u[n-ne-dé-e]
224. .....-an-ṣi-en GÌR-kur-TÚG ná-ba-an-ṣi-en
225. .....-a.....-dè-en-si-en
226. .....-dè-en-si-en
227. .....-šè
228. .....-ra-àm
229. .....
230. .....
231. .....-ni
232. .....-na-.....-eš
233. .....-ni

234. ..... dug$_4$(?)-ga-na-ab-ṣi-en
235. .....-ṣi-en
236. .....-mu(?)-ta(?) ..... KA .... ba-e-dè-en-ṣi-en
237. ..... dug$_4$(?)-ga(?) ..... en(?) ṣi-en
238. ..... ib(?)-tar(?)-ri(?)-en-ṣi-en
239. .....-dè-en-ṣi-en
240. a-a .....-ab-ṣi-en
241. a-a .....-na(?) kug(?)-e-dè šu nam-ba-bu-i-en-ṣi-en
242. a-?-tu(?) .....-na(?) kug-e-dè šu nam-ba-bu-i-en-ṣi-en
243. uzu-níg-sìg-ga-^{giš}kak-ta-lá-a ní-me-lám dug$_4$-ga-na-ab-ṣi-en
244. gíš-àm ú-nam-ti-la gíš-àm a-nam-ti-la ugu-na
šub-bu-dè-en-ṣi-en
245. ^{d}inanna ḫa-ba-gub

Break of 20(?) lines.

266. .....^{giš}kak-ta .....
267. kug-^{d}ereš-ki-gal-la-la-ke$_4$ ka[la-tur-kur-gar-ra
mu-ne-ni-ib-gi$_4$-gi$_4$]
268. uzu-ám-sìg me-ám ga(?) .....
269. uzu-níg-giš(?)-ra(?)-a ÁG(?)-ḫúl(?)-la ..... ? me(?)-teš(?)
in-na-[an-dug$_4$-gi-eš]
270. uzu-níg-sìg^{giš}kak-ta-lá-a ní-me-lám(?) ?-uš
271. gíš ú-nam-ti-la gíš a-nam-ti-la ugu-na bí-in-šub-bu-uš
272. ^{d}inanna ba-gub
273. ^{d}inanna kur-ta ba-e$_{11}$-dè
274. ^{d}a-nun-na-ke$_4$-ne ba-ab-zaḫ-aš
275. a-ba-àm-lú-kur-ra-ke$_4$-ne kur-ra silim-ma-bi e$_{11}$-dè
276. u$_4$-da ^{d}inanna kur-ta ba-e$_{11}$-dè
277. ug$_5$-ga sag-a-na ha-ba-ab-sì-mu
278. ^{d}inanna kur-ta ba-e$_{11}$-dè
279. galla-tur-tur gi-igi-dù-ra(?)-gim
280. galla-gal-gal gi-dub-ba-na-ke$_4$
281. zag-ga-na ba-an-dib-bi-eš
282. lú-igi-na-dib .....-nu-me-a gišdar šu bi-in-du$_8$
283. bar-ra-na-dib .....-nu-me-a ^{giš}tukul úr-ra bí-in-lá
284. lú-e-ne-ra-in-ši-súg-eš-àm
285. lú-^{d}inanna-ra-in-ši-súg-eš-àm
286. ú-nu-zu-me-eš a-nu-zu-me-eš
287. zi-dub-dub-ba-nu-kú-me-eš
288. [kaš(?)]-bal-bal nu-nag-nag-me-eš
289. úr-lú-ka dam šu-ti-a-me-eš
290. ?-umme-da-lá-ka dumu-šu-ti-a-me-eš
291. ^{d}inanna kur-ta ba-e$_{11}$-dè
292. ^{d}inanna kur-ta e$_{11}$-da-ni
293. [sukkal-a-ni] ^{d}nin-šubur-ke$_4$ gìr-ni-šè ba-an-šub
294. saḫar-ra ba-da-an-tuš ^{túg}mu-sír-ra ba-an-mu$_4$
295. galla-e-ne kug-^{d}inanna-ra gù mu-un-na-dé-e
296. ^{d}inanna uru-zu-šè gub-ba e-ne ga-ba-ab-túm-mu-dè
297. kug-^{d}inanna-ke$_4$ galla-e-ne mu-na-ni-ib-gi$_4$-gi$_4$
298. sukkal-e-ne-èm-šag$_5$-šag$_5$-ga-mu
299. ra-gaba-e-ne-èm-gi-en-gi-na-mu
300. na-ri-ga-mu šu nu-mu-un-bar-ri
301. e-ne-èm-dug$_4$-ga-mu gú-zal la-ba-pàd
302. an du$_6$-du$_6$-da ma-an-gá-gá
303. èš-gú-en-na ma-an-tuku-a

304. é-dingir-ri-e-ne-ke$_4$ ma-an-nigin
305. i-bí-ni ma-an-ḪUR ka-ni ma-an-ḪUR
306. ki(?)-mu-lu-da u-di-ṣu-gal-a-ni ma-an-ḪUR
307. mu-lu-nu-tuku-gim túg-aš-a im-ma-an-mu$_4$
308. é-kur-ra-é-^{d}mu-ul-líl-lá-šè
309. urí^{ki}-ma é-^{d}nanna-šè
310. uru-ṣi-ib^{ki} é-^{d}am-an-ki-ga-šè
311. e-ne ma-a-ra mu-un-ti-li-en
312. ga-an-ši-súg-dè-en umma^{ki}-a sig$_4$-kur-šà-ga-šè ga-an-ši-súg-dè-en
313. umma^{ki}-a sig$_4$-kur-šà-ga-ta
314. ^{d}šara gìr-ni-šè ba-an-šub
315. saḫar-ra ba-da-an-tuš ^{túg}mu-sír-ra ba-an-mu$_4$
316. galla-e-ne kug-^{d}inanna-ra gù mu-na-dé-e
317. ^{d}inanna uru-zu-šè gub-ba e-ne ga-ba-ab-túm-mu-dè
318. kug-^{d}inanna-ke$_4$ galla-e-ne mu-na-ni-ib-gi$_4$-gi$_4$
319. ià(?)-giš(?)-máš(?)-gud(?) .....
320. ? ..... gú-TAR-lá .....
321. NE-ta gim-nam ḫ[i(?)-l]i(?)-aš(?) ṣi-èm(?) .....
322. ga-e-súg-en-dè-en bàd-tibira^{ki}-a é-mùš-kalam-ma-šè ga-an-ši-súg-en-dè-en
323. bàd-tibira^{ki}-a é-mùš-kalam-ma-ta
324. ^{d}.....-e gìr-ni-šè ba-an-šub
325. saḫar-ra ba-da-an-tuš ^{túg}mu-sír-ra ba-an-mu$_4$
326. galla-e-ne kug-^{d}inanna-ra gù mu-na-dé-e
327. ^{d}inanna uru-zu-šè gub-ba e-ne ga-ba-ab-túm-mu-dè
328. kug-^{d}inanna-ke$_4$ galla-e-ne mu-un-na-ni-ib-gi$_4$-gi$_4$
329. ..... á-zi-da-gùb-bu-mu-uš .....
330. ..... -ib-ṣi-èm .....
331. ..... -la ga-sì kul-aba[^{ki}]-...
332. ..... kul-aba^{ki}-a .....
333. ..... AN .....

Break of 40(?) lines.

374. .....
375. ..... kur-kur-ra .....
376. ..... NE(?) ki(?)-tuš(?)-bi .....
377. ..... šub(?)-šub(?)-ba mu-un-ri-eš
378. ..... -ni i-in-sìg-gi-ne
379. ..... e(?)-ne i-lu mi-ni-ib-bi-ne
380. ..... -e ?-ni bí-in-šub-bu-uš
381. ..... gú(?)-giš dùg(?) súg(?)-súg(?)-e-dè
382. ..... šu-ni mi-ni-in-dù-dù
383. ..... -kur-kur-ra igi mi-ni-ib-íl-íl-i
384. ..... -ne-ne ..... -ga(?)-me-eš me-luḫ(?) ? kal-la-mu

Notes on the Transliteration

The texts on which the reconstruction of our myth is based are as follows:

Lines	1–208	A(=Ni 368+CBS 9800)i–iv
	1–49	B(=CBS 13932) obv. and rev.
	1–48	C(=CBS 12368+12702+12752) obv. and rev.
	3–25	D(=Ni 2279) obv. (rev. destroyed)
	52–95	E(=CBS 13908) obv. and rev.
	88–94	F(=Ni 4034) obv. (rev. destroyed)
	95–141	G(=CBS 11064+11088) obv. and rev.
	129–137	H(=HGT No. 24)
	144–204	I(=CBS 15212) obv. and rev.
	207–244	J(=Ni 4200) obv. and rev.
	225–242	K(=Ni 2762) obv.
	265–323	L(=CBS 13902) obv. and rev.
	273–295	K rev.
	302–313	M(=CBS 15162) obv.
	354[4]–364	M rev.

The upper half of A (*cf.* Pls. 1 and 2), Ni 368, is in the Museum of the Ancient Orient at Istanbul. It was first published by Langdon in BE XXXI No. 33 and then republished by Chiera in SRT No. 53 (for corrections to the latter, *cf.* Kramer, RA XXXVI pp. 76–80). The lower half of A, CBS 9800, is in the University Museum at Philadelphia. It was first published by me in photographic form in RA XXIV p. 93 ff. B and C (*cf.* Pls. 3 and 4) have been published by Chiera in SEM Nos. 49 and 50. D has been published by Langdon in BE XXXI No. 34 (for corrections, *cf.* Kramer, JAOS 60 p. 246). In the case of E (*cf.* Pl. 5), its reverse only has been published by Chiera in SEM No. 48. F (*cf.* Pl. 10) was copied by me in the Museum of the Ancient Orient at Istanbul. G (*cf.* Pl. 6) has been published by Poebel in HGT No. 23 (*cf.* also *ibid.* Pl. XCIV). H has been published by Poebel in HGT No. 24. I (*cf.* Pl. 7) has been published by me in BASOR No. 79 p. 18ff. J and K (*cf.* Pl. 8) have been published by me in RA XXXVI p. 68ff. L (*cf.* Pl. 9) has been published by Poebel in HGT No. 22. M (*cf.* Pl. 10) has been discovered and copied by me recently in the University Museum at Philadelphia.

[4] The break in M between the last line of its obverse and the first line of its reverse is assumed to contain 40 lines.

The reconstruction of the myth *Inannas' Descent to the Nether World* together with the transliteration and translation as presented in this study is intended to supersede that published by me in RA XXXIV pp. 93–134, RA XXXVI pp. 68–80, and BASOR No. 79 pp. 18–27.

Line 1.—For omission in SRT 53, *cf.* RA XXXVI p. 76.

Line 3.—In D the second sign is Inanna, not N U N.

Line 4.—D omits the -e- of b a - e - a - e_{11} in this and the following lines.

Lines 7–13.—A omits the refrain k u r - r a b a - e - a - e_{11} in these lines. In B the list of cities and temples is identical with that of A, only the order varies; thus: Uruk, Zabalam, Adab, Agade, Kish, Badtibira, Nippur (*cf.* RA XXXVI pp. 76–7). In line 9, B actually has -g a for the expected -n a in g i - g u_{16}^{ki} - n a; this is probably a scribal error. In line 13, B adds -a after a - g a - d è^{ki} and also after é - u l - m a š^{ki}. C lists only two cities and temples; the names are destroyed.

Line 15.—B has -u_8- for -u n- in m u - u n - g á l; in C the verb reads [m u] - u n - g a r.

Line 16.—D has - D Ù G for - D U in m e - D U; in D the verb reads u m - m i - i n - [D U].

Lines 17–25.—The order of these lines is based on A; in B the order is: 17, 18, 21, 20, 23, 24, 25, 19, 22 (the latter line is destroyed); in C the order is: 17, 18, 23, 24, 22, 20, 21, 15, 19; in D the order is: 17, 18, 24, 23, 22, 20, 21 (19 and 25 are destroyed). In line 18, B omits the -n a of s a g - g á - n a. Note the corrected reading of line 19, the sign following - Š È - is G Á N (not G Á); *cf.* the erroneous reading in RA XXXIV p. 99 (especially note 9); *cf.* also BASOR No. 79 p. 24, note 9. For š u m i - n i - i n - d u_8 of this line C has š u - n a b a - a n - d u_8. In line 20, not only D but also A and C have - l á after - t u_{19} - t u_{19} (Chiera's copies are to be corrected accordingly), only B omits the - l á. In line 21, the verb reads b a - a n - s i in B and C; in B the sign copied by Chiera as G I M is B A written over an erasure. In C the verbal form of line 22 reads b a - a n - d u_8. In line 23 note that A seems to insert a sign after the g a b a of g a b a - n a; *cf.* BASOR No. 79 p. 24, especially note 8. In line 24, A omits the -a after the first p a l à -; D omits the determinative before the second - p a l à -; C, no doubt as the result of a scribal error, actually has b a r - b i for the expected b a r - r a - n a.

Note that the last sign in this line is DUL (*i.e.* ROEC 542) and SRT 53 is to be corrected accordingly; *cf.* RA XXXVI p. 77. In line 25, C has -ni for the -na of igi-na, and -íb- for the -in- of ba-ni-in-gar.

Lines 26–27.—Both lines are omitted in C.

Line 28.—C has the expected nin- for ga-ša-an-.

Lines 29–31.—In C, line 29 reads: [gá-nu sukkal]-zi-é-an-na-mu; in line 31, C omits the -en- of -en-na-mu. B has a variant reading for ll. 29–31, as follows:

[gá-n]u šukkal-zi-é-an-na-mu
[na] ga-e-ri na-ri-mu ḫé-[díb]
[inim] ga-ra-ab-dug$_4$ gештug X[5]
ḫé-[im-ma-ag]

Line 32.—In C the verb reads e$_{11}$-dè-en; it lacks the expected prefix.

Line 33.—In C the verb reads e$_{11}$-dè-mu-dè.

Lines 34–40.—In lines 34, 35, 36, and 40, B has the indicative forms mu-un-na-gá-gá, mu-un-na-tuku-a, mu-un-na-nigin, and mu-un-[gub] instead of the imperative forms; these variants are no doubt the result of a scribal error. In line 40, C seems to have a verbal form ending in -na instead of the expected gub-mu-un.

Line 42.—B has IGI- for i-bí-, and -àm for -a.

Lines 43–47.—In line 44, B has -da-ab- for -an-da- in the verb. In l. 45, B omits the -ma- after -zadim-; it reads -si-il-si-il for -si-il-li in the verb; C has -ab- for -an- in the verb. In line 46, A inserts -nam between giš- and -nagar- (also in lines 55, 63).[6] The verb in line 46 probably reads nam-ba-da-dar-dar-ri in A; in B and probably in C, it reads nam-ba-an-dar-dar-e.

Line 48.—C inserts -mu-e- before the -ri- of nu-ri-gub.

Line 50.—B has -kur-ra- for -kalam-ma-.

Line 55.—E has -si-il-si-il for -si-il-li.

Line 59.—E has -àm for -a after -šéš-.

Line 62.—E omits the determinative na$_4$ and has -si-il-si-il for -si-il-li.

Line 67.—E probably inserts -a- after the ma- of ma-ra, and probably omits the ḫu- of the verb. A adds -en after -li-.

Lines 68–69.—Between these two lines E inserts a line reading:

sukkal-a-ni-^{d}nin-šubur-ra
[zag(?)]-a-na i-im-DU

Cf. line 27.

Line 74.—Line omitted in E.

Lines 75–76.—In E these two lines are written as three, thus:

é gál-lu ì-[du$_8$ é gál-lu]
ì-du$_8$ é gál-lu ^{d}[NE-ti é gál-lu]
ì-du$_8$ é gál-lu aš-mu-šè ga-tu

Line 78.—E has -ke$_4$ for -ra (scribal error) and omits the -un- of the verb.

Line 80.—E inserts -an- between -an- and -na; B has -šè for -aš.

Line 81.—E has an-na for ^{d}inanna.

Line 82.—E omits -àm.

Line 83.—E inserts -ù- between -du- and -bi-.

Line 90.—F inserts -un- after mu- in the verb.

Line 94.—F has -šè for -ra after -la-.

Lines 100–111.—For restoration, *cf.* lines 14–25. Note that A is inconsistent in the order arrangement of lines 24–25 and the corresponding lines 110–111. In G, the order of the lines varied from that of A, but the surface is too badly broken for a detailed account.

Line 117.—For the restoration of the line, *cf.* line 123 which is based on G. In A, the line seems to read:

ká-gal-IGI.ZA.KUR...kur-ra(?).....

In G, too, the traces do not point to the same reading of the line as that restored from line 123.

Line 118.—Restorations that are quite certain because of continued repetitions are not bracketed.

Lines 126–127.—In line 126, G has ^{d}inanna for e-ne. Instead of line 127, G substitutes the text of line 132, and follows it by two lines reading:

ká-gal-diš-kam-ma tu-tu-da-ni-ta
^{túg}šu-gur-ra-men-edin-na-sag-gá-na lú ba-da-an-şi-ir

Line 132.—In G the line reads:

ḫi-li-sag-ki-na lú ba-da-an-şi-ir

[5] For the form of the sign, cf. SRT No. 6 obv. 27–8, and TRS No. 22, line 8

[6] So also in line 55; in l. 63, however, A inserts -an- between -da- and -dar-.

Line 137.—In G the line reads:

^{na4}nunuz-tab-ba-zag-ga-na lú
ba-da-an-ṣi-ir

Line 142.—I substitutes the text of line 157.

Line 157.—I substitutes the text of line 132.

Line 161.—*Cf.* line 119.

Line 163.—SRT No. 53 iii 22 is to be corrected accordingly.

Line 166.—This line is omitted in I.

Line 168.—I omits the -ga after -sìg-; it has -an-ta- for -da-an- in the verb.

Line 169.—I has àm- for um-ta- in the verb.

Line 171.—A has the Emesal form -e-ne-èm- for -inim-.

Line 172.—A has the Emesal form -e-ne-èm- for -inim; I omits the -en- of -en-na-ni and has -mu for -ni (scribal error). Following line 172, I inserts two additional lines:

[na]-ri-ga-ni šu nu-bar-ri
[inim]-dug$_4$-ga-ni gú-zal la-ba-pàd

Line 178.—A probably has -ab- for -an- in the verb.

Line 179.—I has the Emesal form -mu-ul-líl- for -en-líl.

Line 180.—I has the Emesal form -mu-ul-líl- for -en-líl-. For tu-tu-da-ni-ta, A seems to have a variant reading which is illegible.

Line 183.—In A the last sign is -e instead of -ri.

Line 184.—I omits -ma- after -zadim-, and has -si-il-si-il for -si-il-li.

Line 185.—In I the last sign is -e instead of -ri.

Lines 188–191.—For restoration of this passage and that of lines 202–205, *cf.* RA XXXVI pp. 79–80 and BASOR No. 79, p. 27. Note that in line 190, there is probably nothing missing after bí-in-dug$_4$. In line 191, the transliteration assumes that there is nothing missing between in-na-an-dug$_4$ and al.

Line 193.—Note that A writes -kur-ra- in this line although it writes -kalam-ma- in the corresponding line 49.

Lines 202–205.—*Cf.* lines 188–191.

Line 209.—Note that in J, the traces of the sign preceding -zu do not point to its restoration as -mu (of the expected ṭu-mu-zu); perhaps the scribe wrote the eme-KU dumu instead.

Line 211.—J omits the -ma- after -zadim-.

Line 213.—J inserts -an- between -an- and -na.

Line 234.—In K the corresponding line seems to end in -eš.

Line 245.—For the size of the break following line 245, *cf.* RA XXXVI p. 74, note 3.

Line 279.—In K the corresponding line is rev. 16.

Lines 280–281.—In K, rev. 17 corresponds to these two lines. Note that K probably has -ka for -ke$_4$ in gi-dub-ba-na-ke$_4$. The verbal form, too, which is badly broken in K, probably varied.

Line 283.—L has mu-un- for bí-in-.

Lines 284–285.—Both lines are omitted in K.

Line 287.—K inserts ù after -kú-.

Line 288.—Between lines 288 and 289, K inserts a line which reads:

..... [šu nu]-
bu-i-me-eš

Line 290.—Following this line, K inserts two lines which read:

..... ur nu-zu (?)
..... [mu]-un-
ur$_4$-ur$_4$-ri-eš

Line 291.—K omits this line.

Line 302.—M omits -en- in the first complex, and -a after bàd-tibira^{ki}; it probably omits the final complex ga-an-ši-súg-en-de-en.

Translation

1. From the ["Great Above"] she set her mind towards the "Great Below",
2. The *goddess*, from the "Great Above" she set her mind towards the "Great Below",
3. Inanna, from the "Great Above" she set her mind towards the "Great Below".

4. My Lady abandoned Heaven, abandoned Earth, to the Nether World she descended,
5. Inanna abandoned Heaven, abandoned Earth, to the Nether World she descended,
6. Lordship she abandoned, Ladyship she abandoned, to the Nether World she descended.

7. In Uruk she abandoned Eanna, to the Nether World she descended,
8. In Badtibira she abandoned Emushkalamma, to the Nether World she descended,
9. In Zabalam she abandoned Giguna, to the Nether World she descended,
10. In Adab she abandoned Esharra, to the Nether World she descended,
11. In Nippur she abandoned Baratushgarra, to the Nether World she descended,
12. In Kish she abandoned Hursagkalamma, to the Nether World she descended,
13. In Agade she abandoned Eulmash, to the Nether World she descended.

14. The seven decrees she fastened at the side,
15. She sought out the decrees, placed them at her hand,
16. *All the decrees she set up at (her) waiting foot,*
17. The Shugurra, the crown of the plain, she put upon her head,
18. *Radiance* she placed upon her countenance,
19. The ..... rod of lapis lazuli she gripped in (her) hand,
20. Small lapis lazuli stones she tied about her neck,
21. *Sparkling* .... stones she fastened to her breast,
22. A gold ring she gripped in her hand,
23. A ..... breastplate she bound about her breast,
24. All the garments of Ladyship she *arranged* about her body,
25. ..... *herbs* she put on her face.

26. Inanna walked towards the Nether World,
27. Her messenger Ninshubur walked at her [*side*].
28. The pure Inanna says to Ninshubur:
29. "Oh (thou who art) my constant support,
30. My messenger of favorable words,
31. My carrier of supporting words,
32. I am now descending to the Nether World.

33. When I shall have come to the Nether World,
34. *Fill* Heaven *with complaints for me,*
35. In the assembly shrine *cry out* for me,
36. In the house of the gods *rush about* for me,
37. *Lower* thy eye for me, *lower* thy mouth for me,
38. With ..... *lower* thy great ..... for me,
39. Like a pauper in a single garment dress for me,
40. To the Ekur, the house of Enlil, direct thy step.

41. Upon thy entering the Ekur, the house of Enlil,
42. Weep before Enlil:
43. 'Oh Father Enlil, let not thy daughter be *put to death* in the Nether World,
44. Let not thy good metal be *ground up* into the dust of the Nether World,
45. Let not thy good lapis lazuli be *broken up* into the stone of the stone-worker,
46. Let not thy *boxwood* be *cut up* into the wood of the wood-worker,
47. Let not the maid Inanna be *put to death* in the Nether World.'

48. If Enlil does not stand by thee in this matter, go to Ur.
49. *In* Ur upon thy entering the house of the .... of the Land,
50. The Ekishshirgal, the house of Nanna,
51. Weep before Nanna:
52. 'Oh Father Nanna, let not thy daughter be *put to death* in the Nether World,
53. Let not thy good metal be *ground up* into the dust of the Nether World,
54. Let not thy good lapis lazuli be *broken up* into the stone of the stone-worker,
55. Let not thy *boxwood* be *cut up* into the wood of the wood-worker,
56. Let not the maid Inanna be *put to death* in the Nether World.'

57. If Nanna does not stand by thee in this matter, go to Eridu.
58. *In* Eridu, upon thy entering the house of Enki,
59. Weep before Enki:
60. 'Oh Father Enki, let not thy daughter be *put to death* in the Nether World,
61. Let not thy good metal be *ground up* into the dust of the Nether World,
62. Let not thy good lapis lazuli be *broken up* into the stone of the stone-worker,
63. Let not thy *boxwood* be *cut up* into the wood of the wood-worker,
64. Let not the maid Inanna be *put to death* in the Nether World.'
65. Father Enki, the Lord of Wisdom,
66. Who knows the food of life, who knows the water of life,
67. He will surely bring me to life."

68. Inanna walked towards the Nether World,
69. To her messenger Ninshubur she says:
70. "Go, Ninshubur,
71. *The word* which I have commanded thee ....."

72. When Inanna had arrived at the lapis lazuli palace of the Nether World,
73. At the door of the Nether World she *acted* evilly,
74. In the palace of the Nether World she spoke evilly:
75. "Open the house, gatekeeper, open the house,
76. Open the house, Neti, open the house, all alone I would enter."

77. Neti, the chief gatekeeper of the Nether World,
78. Answers the pure Inanna:
79. "Who, pray, art thou?"

80. "I am the Queen of Heaven, the place where the sun rises."

81. "If thou art the Queen of Heaven, the place where the sun rises,
82. Why, pray, hast thou come to the Land of No Return,
83. How has thy heart led thee on the road whose traveller returns not?"

84. The pure Inanna answers him:
85. "My elder sister, Ereshkigal,
86. Because her husband, the lord Gugalanna, had been killed,
87. To witness his funeral rites,
88. .....; so be it."

89. *Neti*, the chief gatekeeper of the Nether World,
90. Answers the pure Inanna:
91. "*Stay*, Inanna, to my queen let me speak,
92. To my queen Ereshkigal let me speak ... let me speak."

93. *Neti*, the chief gatekeeper of the Nether World,
94. Enters the [house] of his queen Ereshkigal (and) says to her:
95. "Oh my queen, a maid,
96. Like a god .....,
97. The door .....,
98. .....,
99. In Eanna .....,
100. The seven decrees she has fastened at the side,
101. She has sought out the decrees, has placed them at her hand,
102. *All the decrees she has set up at (her) waiting foot*,
103. The Shugurra, the crown of the plain, she has put upon her head,

104. *Radiance* she has placed upon her countenance,
105. The ..... rod of lapis lazuli she has gripped in (her) hand,
106. Small lapis lazuli stones she has tied about her neck,
107. *Sparkling* .... stones she has fastened to her breast,
108. A gold ring she has gripped in her hand,
109. A ..... breastplate she has bound about her breast,
110. ..... *herbs* she has put on her face,
111. All the garments of Ladyship she has *arranged* about her body."

112. Then Ereshkigal .....,
113. [Answers] *Neti*, her chief gatekeeper:
114. "Come, Neti, [chief] gatekeeper of the [Nether World],
115. *Unto the word which I command thee*, [*give ear*].
116. Of the seven gates of the Nether World, [open their locks],
117. Of the gate [Ganzir, the face of the Nether World, define its rules].
118. Upon her entering,
119. Bowed low ..... let her ....."

120. *Neti*, the chief gatekeeper of the Nether World,
121. Honored the word of his queen.
122. Of the seven gates of the Nether World, [he opened] their locks,
123. Of the gate, Ganzir, the face of the Nether World, [he defined] its rules.
124. To the pure Inanna he says:
125. "Come, Inanna, enter."

126. Upon her entering,
127. The Shugurra, the crown of the plain of her head was removed.
128. "*What, pray, is this?*"
129. "Extraordinarily, Oh Inanna, have the decrees of the Nether World been perfected,
130. Oh Inanna, *do not question* the rites of the Nether World."

131. Upon her entering the second gate,
132. The ..... rod of lapis lazuli was removed.
133. "*What, pray, is this?*"
134. "Extraordinarily, Oh Inanna, have the decrees of the Nether World been perfected,
135. Oh Inanna, *do not question* the rites of the Nether World."

136. Upon her entering the third gate,
137. The small lapis lazuli stones of her neck were removed.
138. "What, pray, is this?"
139. "Extraordinarily, Oh Inanna, have the decrees of the Nether World been perfected,
140. Oh Inanna, *do not question* the rites of the Nether World."

141. Upon her entering the fourth gate,
142. The *sparkling* .... stones of her breast were removed.
143. "What, pray, is this?"
144. "Extraordinarily, Oh Inanna, have the decrees of the Nether World been perfected,
145. Oh Inanna, *do not question* the rites of the Nether World."

146. Upon her entering the fifth gate,
147. The gold ring of her hand was removed.
148. "What, pray, is this?"
149. "Extraordinarily, Oh Inanna, have the decrees of the Nether World been perfected,
150. Oh Inanna, *do not question* the rites of the Nether World."

151. Upon her entering the sixth gate,
152. The ..... breastplate of her breast was removed.
153. "What, pray, is this?"
154. "Extraordinarily, Oh Inanna, have the decrees of the Nether World been perfected,
155. Oh Inanna, *do not question* the rites of the Nether World."

156. Upon her entering the seventh gate,
157. All the garments of Ladyship of her body were removed.
158. "What, pray, is this?"
159. "Extraordinarily, Oh Inanna, have the decrees of the Nether World been perfected,
160. Oh Inanna, *do not question*, the rites of the Nether World."

161. Bowed low .....
162. [The pure Eresh]kigal [seated] herself upon her throne,
163. The Anunnaki, the seven judges, [pronounced] judgment before her,
164. They fastened (their) eyes upon her, the eyes of death.
165. *At* their [word], the word which tortures the spirit,
166. .....,
167. *The sick* [*"woman"*] was turned into a *corpse*,
168. The *corpse* was hung from a *stake*.

169. After three days and three nights had passed,
170. Her messenger Ninshubur,
171. Her messenger of favorable words,
172. Her carrier of supporting words,
173. *Fills* the Heaven *with complaints for her*
174. *Cried out* for her in the assembly shrine,
175. *Rushed about* for her in the house of the gods,
176. *Lowered* his eye for her, *lowered* his mouth for her,
177. *With* ..... he *lowered* his great ..... for her,
178. Like a pauper in a single garment he dressed for her,
179. To the Ekur, the house of Enlil, he directed his step.

180. Upon his entering the Ekur, the house of Enlil,
181. Before Enlil he weeps:
182. "Oh Father Enlil, let not thy daughter be *put to death* in the Nether World,
183. Let not thy good metal be *ground up* into the dust of the Nether World,
184. Let not thy good lapis lazuli be *broken up* into the stone of the stone-worker,
185. Let not thy boxwood be *cut up* into the wood of the wood-worker,
186. Let not the maid Inanna be *put to death* in the Nether World."

187. Father Enlil answers Ninshubur:
188. "My daughter, in the "[Great] Above" ..... in the "Great Below" .....,
189. Inanna, in the "[Great] Above" ..... in the "Great Below" .....,
190. The decrees of the Nether World, the ..... decrees, to their place .....,
191. Who, pray, *to* their place .....?"

192. Father Enlil [did not stand by him] in this matter, he [went] to Ur.
193. *In* Ur, upon his entering the house of the .... of the land,
194. The Ekishshirgal, the house of Nanna,
195. Before Nanna he weeps:
196. "Oh Father Nanna, let not thy daughter be *put to death* in the Nether World,
197. Let not thy good metal be *ground up* into the dust of the Nether World,
198. Let not thy good lapis lazuli be *broken up* into the stone of the stone-worker,

199. Let not thy boxwood be *cut up* into the wood of the wood-worker,
200. Let not the maid Inanna be *put to death* in the Nether World."

201. Father Nanna answers Ninshubur:
202. "My daughter, in the "[Great] Above" ..... in the "Great Below" .....,
203. Inanna, in the "[Great] Above" ..... in the "Great Below" .....,
204. The decrees of the Nether World, the ..... decrees, to their place .....,
205. Who, pray, *to* their place .....?"

206. Father Nanna [did not stand by him] in this matter, [he went to Eridu].
207. *In* Eridu, upon his entering the house of Enki,
208. Before Enki he weeps:
209. "Oh Father Enki, let not thy daughter be *put to death* in the Nether World,
210. Let not thy good metal be *ground up* into the dust of the Nether World,
211. Let not thy good lapis lazuli be *broken up* into the stone of the stone-worker,
212. Let not thy boxwood be *cut up* into the wood of the wood-worker,
213. Let not the maid Inanna be *put to death* in the Nether World."

214. Father Enki answers Ninshubur:
215. "What now has my daughter done! I am troubled,
216. What now has Inanna done! I am troubled,
217. What now has the Queen of all the Lands done! I am troubled,
218. What now has the Hierodule of Heaven done! I am troubled."
219. ..... *he brought forth dirt* (and) fashioned the *kurgarrû*,
220. ..... *he brought forth dirt* (and) fashioned the *kalaturru*.
221. To the *kurgarrû* he gave the food of life,
222. To the *kalaturru* he gave the water of life.
223. [Father] Enki sa[ys] to the *kalaturru* and *kurgarrû:*
224. "..... lay .....,
225. .....,
226. .....,
227. .....,
228. .....,
229. .....,
230. .....,
231. .....,
232. .....,
233. .....,
234. .....,
235. .....,
236. .....,
237. .....,
238. .....,
239. .....,
240. .....,
241. To *purify* ..... do not .....,
242. To purify ..... do not .....,
243. *Upon the corpse hung from a stake direct the fearfulness of the melammu,*
244. *Sixty times* the food of life, *sixty times* the water of life, sprinkle upon it,
245. Surely Inanna will arise."

Break of 20(?) lines.

266. ..... *from a stake* .....
267. The pure Ereshkigal answers the *ka*[*laturru* and the *kurgarrû*]:
268. "*The corpse* ....."

269. Upon the smitten flesh they .....
270. *Upon the corpse hung from a stake the fearfulness of the melammu* .....
271. *Sixty times*, the food of life, *sixty times* the water of life, they sprinkled upon it,
272. Inanna arose.

273. Inanna ascends from the Nether World,
274. The Anunnaki fled,
275. (*And*) *whoever of the Nether World that had descended peacefully to the Nether World.*
276. When Inanna ascends from the Nether World,
277. Verily the dead *hasten ahead of her.*
278. Inanna ascends from the Nether World,
279. The small *demons* like ..... reeds,
280. The large *demons like tablet styluses*,
281. Walked at her side.
282. Who *walked* in front of her, *being without* ...., held a staff in the hand,
283. Who *walked* at her side, *being without* ...., carried a weapon on the loin,
284. They who *preceded* her,
285. They who preceded Inanna,
286. (Were beings who) know not food, who know not water,
287. Who eat not sprinkled flour,
288. Who drink not libated [*wine*],
289. Who take away the wife from the loins of the man,
290. Who take way the child from the *breast* of the nursing mother.

291. Inanna ascends from the Nether World.
292. Upon Inanna's ascending from the Nether World,
293. [Her messenger], Ninshubur, threw herself at her feet,
294. Sat in the dust, dressed in *dirt.*
295. The *demons* say to the pure Inanna:
296. "Oh Inanna, *wait before* thy city, *we would bring him to thee.*"
297. The pure Inanna answers the *demons:*
298. "(He is) my messenger of favorable words,
299. My carrier of supporting words,
300. He *fails* not my directions,
301. He *delays* not my commanded word,
302. He *fills* the Heaven *with complaints for me.*
303. In the assembly shrine he *cried out* for me,
304. In the house of the gods he rushed about for me,
305. He *lowered* his eye for me, he *lowered* his mouth for me,
306. *With* ..... he *lowered* his great ..... for me
307. Like a pauper in a single garment he dressed for me,
308. To the Ekur, the house of Enlil,
309. In Ur, to the house of Nanna,
310. *In* Eridu, to the house of Enki (he directed his step).
311. He brought me to life."

312. "Let us *precede* her, in Umma *to the* Sigkurshagga let us *precede* her."
313. In Umma, from the Sigkurshagga,
314. Shara threw herself at her feet,
315. Sat in the dust, dressed in *dirt.*
316. The *demons* say to the pure Inanna:
317. "Oh Inanna, *wait before* thy city, *we would bring him to thee.*"
318. The pure Inanna answers the *demons:*
319. ".....

320. .....
321. ....."

322. "Let us *precede* her, in Badtibira to the Emushkalamma let us *precede* her."
323. In Badtibira from the Emushkalamma,
324. ..... threw *themselves* at her feet,
325. Sat in the dust, dressed in *dirt.*
326. The *demons* say to the pure Inanna:
327. "On Inanna, *wait before* thy city, *we would bring them to thee.*"
328. The pure Inanna answers the *demons:*
329. ..... to my right and left .....
330. .....
331. ..... *I would give*, Kullab .....
332. ..... Kullab .....
333. .....

Break of 40(?) lines.

374. .....
375. ..... all the lands .....,
376. ..... *their dwelling place* .....,
377. ..... they *carried off*,
378. ..... they *smite* (?)
379. ..... a lament they utter
380. ..... they *hurled*
381. .....
382. ..... *she points her finger*
383. ..... all the lands, she lifts her eye
384. .....

Notes on the Translation [7]

Lines 1–3.—The a n - g a l, "Great Above", of the Sumerians is the space above the sky and includes the dwelling places of the "sky" gods. The k i - g a l, "Great Below", is the space below the surface of the earth and includes the dwelling places of the chthonic deities. The n a - of n a - a n - g u b, as Falkenstein has pointed out, is a thematic prefix (my suggestion in RA XXXIV p. 116 is erroneous); it is probably the same prefix which is involved in the Gudea verbal forms listed in GSG §205. The use of the word A N (= d i n g i r (?)) as an epithet of Inanna in the second line of our triplet is unusual, one might rather have expected a term such as n i n - m u or n u - g i g - a n - n a.

Line 8.—The reading m ù š of the sign M Ù Š in é - M Ù Š - k a l a m - m a is not certain but quite probable.

Line 13.—The reading u l of the sign U L in é - U L - m a š^{ki} is not certain but quite probable.

Lines 14–16.—The translation "decrees" for the Sumerian m e is preferable to "rites". While the nature of the "decrees" mentioned in lines 14–16 is as yet quite uncertain, we now know at least how Inanna came into their possession, *cf.* p. 322 No. 12. Since these "decrees" were transported by Inanna on a boat from Eridu to Erech, it is not unlikely that they were conceived as written down on tablets. Perhaps, therefore, it is these tablets which Inanna "fastened at her side", "placed at her hand", etc.[8] With line 14, *cf.* VS X No. 199 ii 16 m e - g a l - g a l - l a z a g m u - n i - i n - k e š d, "He (*i.e.* Anu) fastened the great decrees at his side". In line 15, the - Š È of š u - n i - Š È may of course be transliterated as - é š (*cf.* also lines 94, 163, 191, 192, 204, 205, 273, 314, 324) just as it may be transliterated - u š$_4$ in u r u - z u - Š È (lines 296, 317, 327) and - a š$_{10}$ in s i g$_4$ - k u r - š à - g a - Š È (line 312). In line 16, the translation "all" for the D U of m e - D U is predicated on the bare possibility

[7] These notes are intended to supplement and, wherever necessary, to modify the commentary on the translation in RA XXXIV, RA XXXVI, and BASOR No. 79.

[8] Note, however, that in VS X No. 199 iii 19, Inanna boasts: t ú g - m e - k u g k u š - m à m u - n i - i n - l á, "The pure garment of decrees, he (*i.e.* Enlil) tied about my body." This statement, if it is intended to be taken literally, would seem to indicate that the "decrees", or at least some of them, were part of a special garment.

that it may be a variant of d ù and on the fact that D has the variant D Ù G which may be read š á r, "all".[9]

Line 19.—The g i - d iš - n i n d a - Š È - g á n seems to be the Akkadian *ginindanakku* despite the fact that the syllabaries do not attest the Sumerian form quite as it appears in our text; *cf.* Ungnad in ZA XXXI p. 25.

Line 23.—For t u - d i - t u m, cf. the variant t u - d i - d a in VS II No. 32 i 7.

Lines 26–28.—The root of the word represented by D U, "to go", in i - i m - D U, is transliterated as d u rather than g i n, since to judge from b a - d u - u n, "thou hast come" (line 82) and - d u - ù - b i, literally "its goer" (line 83), it ends in the vowel u. In the Emesal passages, on the other hand, it does seem to have ended with the consonant n, *cf.* the imperative D U - n a (lines 48, 57, 70) and the infinitive D U - n a (line 33). For the unexpected Emesal writings g a - š a - a n (lines 27–28), *cf.* AS XII p. 10, heading 9. For e m e - K U writings in Emesal passages, *cf. ibid.* p. 7 ff.

Lines 29–31.—The translation "supporting" for - g i - e n - g i - e n - n a - (line 31) seems preferable to "true", since the meaning might be expected to parallel the - š a g$_5$ - š a g$_5$ - g a of the preceding line. Note that - š a g$_5$ - š a g$_5$ - g a - and - g i - e n - g i - e n - n a - probably represent the reduplicated š a g$_5$ and g i n rather than š a g$_5$ - a and g i n - a (as suggested in RA XXXVI p. 120), the final a is probably the genitive - a (k). For the reading and meaning of the variant lines in E, *cf.* BASOR No. 79 p. 25, note 25; for the restoration ḫ é - i m - m a - a g, *cf.* SRT No. 6 line 28.[10]

Lines 34–42.—For lines 34–37, *cf.* BASOR No. 79 p. 26. For the translation "lower" for Ḫ U R (lines 37–38), *cf.* perhaps Ḫ U R = *qadâdu* and the phrase *guddud appušu* in *Ishtar's Descent.* In line 40, the first sign in the verbal form is to be read g u b (not t ú m). In line 42, note the corrected reading i - b í - for i g i - k u g -.

Lines 42–47.—Note the corrections in the transliteration and translation of this passage as compared with those of RA XXXIV. For the equation g ú r = *mâtu*, *cf.* especially SBH No. 4 lines 26–27;[11] for the reading g ú r rather than g a m, *cf.* b a - a n - k u r in K 6930. Still difficult is m u - l u of line 43; if the construction involved is that of the passive (*cf.* BASOR No. 79 p. 21, note 5), there seems to be no reason for its use in this particular line and not in any of the following four lines. In line 46, B clearly reads: g i š - n a g a r - r a - k a while A inserts - n a m - before - n a g a r -; the former reading was chosen since n a g a r seems to parallel the z a d i m of the preceding line, *cf.* RA XXXVI p. 77, note 11. To judge from the context both the z a d i m and the n a g a r of our myth are denizens of the Nether World.

Lines 48–50.—For D U - n a (line 48), *cf.* comment to lines 26–28. In line 49, between é - and - k a l a m - is the sign M U D (or perhaps the signs M U Š E N and D Ù G), not the signs N A M and D Ù G. In line 50, there is no é - preceding ^{d}n a n n a - š è.

Lines 52–56.—*Cf.* comment to lines 43–47.

Line 57.—For D U - n a, *cf.* comment to lines 26–28.

Lines 60–64.—*Cf.* comment to lines 43–47.

Lines 65–67.—Note the corrected translation of these lines as compared with that of RA XXXIV. It assumes the - d a - of - d a - m a - a l - has been omitted by scribal error; that e - n e (line 57) refers to Enki; that m a - r a (for the expected m à - e) is a dative of reference (*cf.* comment to lines 284–285) and that ḫ u - m u - u n - t i - l i is a present-future asseverative form of the third person singular.[12]

Lines 68–71.—For i - i m - d u (line 68) and D U - n a (line 70), *cf.* comment to lines 26–28. Note the corrected word division in line 71; the meaning might be expected to approximate: "Do not delay my commanded word." As the line stands at present, however, it is difficult to analyze.

Lines 72–74.—As the translation indicates the u of u m - m a - t e is the conditional u, *cf.* GSG §426; the suggestion offered in RA XXXVI p. 124 seems less likely. Note the corrected reading b a - a n - u š for b a - a n - g á l in line 73.

Line 80.—The - a š (= - š è) of k i - ^{d}u t u -

[9] *Cf.* also VS X No. 199 ii 17: m e - š á r - r a g ìr - n i n a m - m i - i n - g a r, "He (*i.e.* Anu) placed all the decrees at his feet."

[10] In HGT No. 1 (the "deluge" tablet), line 5 of col. iii is probably to be restored: n a - r i - g a - m u g e š t u g X ḫ é - i m - m a - a g, rather than as suggested in BASOR No. 79 p. 26.

[11] The Sumerian reads u m u n - e e - n e - è m - m a - n i ^{gi}é n - p a r (!) T U L - b a à m - m i - i b - g ú r - g ú r. The word ^{gi}é n - p a r is the phonetic form of a m b a r (Akkadian loan word *apparu*). Note, therefore, that the equations to be derived from this passage are: ^{gi}é n - p a r = *apparu* and T U L - b a = *ina šuklisu*, and that ŠL 85: 144 and 74: 348 are to be eliminated.

[12] The final - e n in A's variant, if not a scribal error, remains difficult.

è-a-aš is not the postposition as assumed in RA XXXVI, but the verb šè, "to do", "to make", etc. A more literal translation of ki-^{d}utu-è-a-aš is, therefore, "the place where the sun makes (his) rising"; for this idiomatic and from our point of view pleonastic use of the verbs šè and ag, *cf.* Poebel in AOF IX p. 266.

Line 88.—Note the corrected reading of the line; the translation of the first half of the line in RA XXXIV is therefore erroneous.

Line 91.—Instead of nin-mà the form might have been expected to read nin-mu-ra.

Lines 126–160.—According to this passage, Inanna wore seven bits of apparel which were removed piece by piece as she passed through each of the seven gates of the Nether World. On the other hand, the passage describing Inanna's dress preparatory to her descent consists of nine lines, each of which seems to describe a specific unit of apparel. In A, the removal of the ḫi-li-sa-g-ki-na and the šim(?)-e-ḫé-im-DU-ḫé-im-DU is omitted. In G, it is to be noted, the gi-diš-ninda-ŠÈ-gán was removed even before she entered the first gate, although according to A it was removed at the second gate, and according to I it was removed at the seventh gate. According to G, therefore, it is not impossible that eight bits of apparel were removed. For the expressions lú ba-da-an-ṣi-ir and ta-àm-me-a, *cf.* BASOR No. 79 p. 21. The translation "do not question" for ka-zu na-an-....-e-en is a guess based on the context; the grammatical relationship between ka-zu and the partly broken verbal form still remains uncertain.

Line 161.—*Cf.* RA XXXVI p. 79, comment to col. iii 19, and especially note 6; *cf.* also BASOR No. 79 p. 24.

Lines 162–168.—*Cf.* BASOR No. 79 p. 24 ff. In line 163 it is perhaps the plural form of the verb which is to be restored; note, however, the singular mu-ši-in-bar in line 164. For the unjustified Emesal i-bí (line 164), *cf.* comment to lines 26–28.

Lines 169–178.—Note the incorrect Emesal writings i-bí (line 176) and mu-lu (line 178). In line 177, on the other hand, note the correct writing lú; the corresponding line 38, which is part of Inanna's speech, uses the Emesal mu-lu.

Lines 188–191.—The translation of this significant passage will be impossible as long as the meaning of the compound a'—dug$_4$ remains uncertain.

Lines 209–245.—*Cf.* RA XXXVI p. 68 ff. In line 233, note that the restoration -ne- is preferable to -na- in mu-ne-dé-e, although to judge from lines 277, 318, and 328, it is not impossible that the scribe wrote the grammatically incorrect -na-. For line 243, *cf.* BASOR No. 79 p. 24, line 20.

Lines 246–323.—In line 247, the restoration of -ne- in mu-ne-ni-ib-gi$_4$-gi$_4$ is preferable to -na-, *cf.*, however, preceding note. Line 268 probably contains Ereshkigal's speech, note the Emesal á m for the eme-KU níg. Lines 269–271 describe the action of the *kalaturru* and *kurgarrû*; cf. especially line 270 with line 243 and line 271 with line 244. In line 280, the last sign is KE$_4$, not GIM. In line 284, -ene-ra seems to be a dative of reference; so also -^{d}inanna-ra of line 285; *cf.* comment to lines 65–67. In line 290, the sign preceding -lá- is DA, not GA. In line 295, the translation assumes that galla-e-ne is a plural and that it is the subject of gù mu-un-na-dé-e, although the latter is in the singular. For ga-ba-ab-túm-mu-dè (line 296) *cf.* RA XXXIV p. 112. In line 297, galla-e-ne is assumed to be a plural in spite of the singular infix -na- (for the expected -ne-). For lines 298–307, *cf.* lines 29–39 and lines 170–178. Line 308 is a contraction for the entire passage contained in lines 179–192; line 309 is a contraction for that contained in lines 193–206; line 310 is a contraction for that contained in lines 207–213. In line 311, the translation assumes that ma-ra is a dative of reference and that the final -en of the verbal form is a second person singular accusative element; *cf.* comment to line 67. For ga-an-ši-súg-dè-en (line 312), *cf.* RA XXXIV p. 133 and especially note 2. In line 312, note that the corrected reading of Shara's temple in Umma is sig$_4$-kur-šà-ga; *cf.* TRS No. 15 obv. ii 12: é-bi umma sig$_4$-kur-šà-ga[13] and the Emesal form SIG$_4$(!)-kur-šà(!)-ba in PBS X 2 No. 4 rev. 16. In line 324, if no error is involved the verb is a third person plural preterit.

Lines 374–384.—In its present fragmentary state it would be futile to attempt any definitive interpretation of the passage.

[13] A collation of the duplicate STVC No. 66 rev. i 15 shows it to begin with: é-bi umma (!)^{ki}-a sig$_4$(!)-kur-šà-ga-ke$_4$.

Excursus A

The Decipherment of Sumerian

The decipherment of Sumerian differed from that of Assyrian and Egyptian in one significant detail, a detail which proved to be one of the factors in hampering the progress of Sumerology to no inconsiderable extent. For in the case of both Egypt and Assyria, the investigating scholars of western Europe had at their disposal much relevant material from Biblical, classical and post-classical sources. Not only were such names as Egypt, Ashur, Babylon, etc. well known, but at least to a certain extent and with much limitation and qualification, even the history and culture of the peoples were not altogether unfamiliar to them. In the case of the Sumerians, however, the situation was quite different; *there was no recognizable trace of Sumer or its people and language in the entire Biblical, classical, and post-classical literature.* The very name Sumer was erased from the mind and memory of man for over two thousand years. The discovery of the Sumerians and their language came quite unexpectedly and was quite unlooked for, and this more or less irrelevant detail was at least partially responsible for the troubled progress of Sumerology from the earliest days to the present moment.

Historically, the decipherment of Sumerian resulted from that of Assyrian which in turn followed the decipherment of cuneiform Persian. Briefly sketched, the process was as follows: In 1765, the Danish traveller and scholar, Carsten Niebuhr, succeeded in making careful copies of several inscriptions on the monuments of Persepolis. These were published between the years 1774 and 1778, and were soon recognized as trilingual, *i.e.* the same inscription seemed to be repeated in three different languages. It was not unreasonable to assume, since the monuments were located in Persepolis, that they were inscribed by one or more kings of the Achaemenid dynasty and that the first version in each inscriptions was in the Persian language. Fortunately, at approximately the same time, Old Persian was becoming known to western European scholars through the efforts of Duperron who had studied in India under the Parsees and was preparing translations of the Avesta. And so by 1802, with the help of the newly acquired knowledge of Old Persian and by a keen manipulation of the Achaemenid proper names as handed down in Biblical and classical literature, the German scholar, Grotefend, succeeded in deciphering a large part of the Persian version of the inscriptions. Additions and corrections were made by numerous scholars in the ensuing years. But the crowning achievement belongs to H. C. Rawlinson. A member of the English Intelligence Service, Rawlinson was first stationed in India where he mastered the Persian language. In 1835 he was transferred to Persia where he learned of the huge trilingual inscription on the Rock of Behistun and determined to copy it. The Persian version of the Behistun inscription consists of 414 lines; the second, now known as the Elamite version, consists of 263 lines, while the third, or Assyrian version, consists of 112 lines. During the years 1835–7, at the risk of life and limb, Rawlinson succeeded in copying 200 lines of the Persian version. He returned in 1844 and completed the copying of the Persian as well as the Elamite version. The Assyrian inscription, however, was so situated that it was impossible for him to copy it and it was not until 1847 that he succeeded in making squeezes of the text. To return to the decipherment of cuneiform Persian, by 1846 Rawlinson published his memoir in the *Journal of the Royal Asiatic Society* which gave the transliteration and translation of the Persian version of the Behistun inscription together with a copy of the cuneiform original.

Long before the final decipherment of the Persian text, however, great interest had been aroused in western Europe by the third version of the Persepolis inscriptions. For it was soon recognized that this was the script and language found in numerous inscriptions on bricks, clay tablets, and clay cylinders which were finding their way into Europe from sites that might well be identified with Nineveh and Babylon. In 1842, the French under Botta began the excavation of Khorsabad and in 1845, Layard began his excavations of Nimrud and Nineveh. Inscribed monuments were being found in large quantities in all three sites; moreover Layard was uncovering at Nineveh a large number of inscribed clay tablets. By 1850, therefore, Europe had scores of inscriptions coming largely from Assyrian sites inscribed in the very same script and language as the third version of the Persepolis and Behistun inscriptions. The decipherment of Assyrian, the name soon given to this language, was simplified on the one hand by the fact that it was recognized quite early in the process that it belonged to the Semitic group of languages.

On the other hand, it was complicated seriously by the fact that the orthography, as was soon recognized, was syllabic and ideographic rather than alphabetic. The leading figure in the decipherment of Assyrian was the Irish scholar, Edward Hincks. But once again a major contribution was made by Rawlinson. In 1851 he published the text, transliteration and translation of the Assyrian version of the Behistun inscription, the large trilingual to which he alone had access.

As for the second, or Elamite, version of the Behistun inscription, it offered relatively little difficulty as soon as progress was made in the decipherment of Assyrian, since it uses a syllabary based on the latter system of writing. The major figures in its decipherment were Westergaard and Norris. As early as 1855, Norris, the secretary of the Royal Asiatic Society, published the complete text of the second version of the Behistun inscription which had been copied by Rawlinson together with a transliteration and translation; this remained practically the standard work on the subject until Weissbach published his *Achamenideninschriften zweiter Art* in 1896.

As will be noted, nothing has as yet been heard or said of the Sumerians. As early as 1850, however, Hincks began to doubt that the Semitic Assyrians had invented the cuneiform system of writing. In the Semitic languages the stable element is the consonant while the vowel is extremely variable. It seemed unnatural, therefore, that the Semites should invent a syllabic system of orthography in which the vowel seemed to be as unchanging as the consonant. Moreover, if the Semites had invented the script, one might have expected to be able to trace the syllabic values of the signs to Semitic words. But this was hardly ever the case, the syllabic values all seemed to go back to words or elements for which no Semitic equivalents could be found. Hincks thus began to suspect that the cuneiform system of writing was invented by a non-Semitic people who had preceded the Assyrians in Mesopotamia. In 1855, Rawlinson published a memoir in the *Journal of the Royal Asiatic Society* in which he speaks of his discovery of non-Semitic inscriptions on the bricks and tablets from sites in southern Babylonia such as Nippur, Senkereh, and Erech. In 1856, Hincks took up the problem of this new language, recognized that it was agglutinative in character and gave the first examples from bilinguals which had come to the British Museum from the Nineveh Excavations. The name of the language was variously designated as Scythic or Accadian. But in 1869, the French scholar Oppert, basing himself on the royal title "king of Sumer and Accad" and realizing that Accad was equated with the Semitic Assyria, rightly attributed the name Sumerian to the language spoken by the non-Semitic people who had invented the cuneiform script. Nevertheless, Oppert was not immediately followed by most of the Assyriologists, and the name Accadian which is now used to designate the Semitic population and language of Assyria and Babylonia, continued to be used for Sumerian for many years to come.[14]

For several decades following the discovery of the existence of Sumerian, practically all the source material for its decipherment and study consisted of the bilinguals and syllabaries from the so-called Ashurbanipal library which was discovered and excavated in Nineveh. This material dates from the seventh century B.C., more than fifteen hundred years after the disappearance of Sumer as a political entity. As for the material from the Sumerian sites, it consisted almost entirely of a very small group of bricks, tablets and cylinders from the Sumerian and post-Sumerian periods which had found their way into the British Museum. In 1877, however, began the excavation of Tello, ancient Lagash, an excavation which has been conducted by the French intermittently and with long periods of rest almost to the present day. It was at this site that the first important Sumerian monuments were excavated, the monuments and inscriptions of the *ishakku's* or "princes" of Lagash. Here more than one hundred thousand tablets and fragments were dug up dating from the pre-Sargonid, Sargonid and Ur III periods.[15]

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[14] As a matter of historic curiosity it is noteworthy to mention that in spite of all evidence to the contrary, the well known Orientalist, J. Halévy continued to deny the existence of a Sumerian people and language in Babylonia, as late as the first decade of the twentieth century. According to his biased and subjectively motivated views, no people other than the Semites had ever been in possession of Babylonia. As for the so-called Sumerian language, it was merely an artificial invention of the Semites devised for esoteric purposes.

[15] The first forty thousand tablets were discovered by the Arab workers while De Sarzec, the excavator happened to be away from the mound. They succeeded in getting them all into the hands of dealers, and as a result there is not an important collection in Europe or America which does not have some Lagash tablets. In the Muesum of the Ancient Orient, the tablets excavated at Lagash are

The second major excavation of a Sumerian site was that conducted by the University of Pennsylvania at Nippur between the years 1889 and 1900. From the point of view of inscriptional finds, this excavation is probably the most important conducted on any Sumerian site to date. Approximately thirty thousand tablets and fragments were excavated at Nippur. Because of the variety of their contents they furnish more significant source material than the much larger number of tablets excavated at Lagash. Of the thirty thousand Nippur tablets, some are Semitic and date from the Hammurabi, Kassite, and Neo-Babylonian periods. Most of the Nippur tablets, however, are Sumerian. They contain a great variety of economic documents dating from the pre-Sargonid, Sargonid and Ur III periods, *i.e.* from approximately 2800 to 2000 B.C. They contain, too, a considerable number of lexical and grammatical texts; it was this group of Nippur tablets which furthered to no small extent the formulation of the principles of Sumerian grammar. *But the unique and most significant part of the Nippur material consists of more than two thousand "literary" tablets and fragments dating from the early post-Sumerian period, i.e. from about* 2000 B.C.[16]

Following Nippur, the excavations by the Germans of Fara (ancient Shuruppak) in 1902–3 and that by the University of Chicago at Bismaya (ancient Adab) in 1903–4, uncovered important Sumerian economic and lexical material dating largely from the pre-Sargonid and Sargonid periods. Excavations at Kish, begun by the French in 1911 and continued under Anglo-American auspices from 1922 to 1930, have yielded important inscriptional material. In Jemdet Nasr, not far from Kish, a large group of semi-pictographic tablets that go back to the early beginnings of Sumerian writing, have been excavated. Ur, the famous site excavated by a joint expedition of the British Museum and the University Museum between the years 1919 and 1933, yielded many historical and economic inscriptions and some literary material. In Asmar and Hafaji, east of the Tigris, a large number of economic tablets dating largely from the Sargonid and Ur III periods, were excavated by the Oriental Institute of the University of Chicago in recent years. Finally in Erech, where the Germans conducted excavations from 1928 until the outbreak of the war, a large group of pictographic Sumerian tablets antedating those found at Jemdet Nasr have been uncovered.

This brief survey furnishes a bird's-eye view of the Sumerian inscriptional finds uncovered and brought to light by legitimate excavations. In addition, scores of thousands of tablets have been dug up clandestinely by the native Arabs in the mounds of Sumer, especially in the ancient sites of Larsa, Sippar, and Umma. It is therefore difficult to estimate the number of Sumerian tablets and fragments now found in museums and in private collections; a quarter of a million is probably a conservative guess. What, now, is the nature of the contents of this vast amount of Sumerian inscriptional material? What significant information can it be expected to reveal?

In the first place it is important to note that *more than ninety-five percent of all the Sumerian tablets are economic in character, i.e.* they consist of notes and receipts, contracts of sale and exchange, agreements of adoption and partnership, wills and testaments, lists of workers and wages, letters, etc. Because these documents follow a more or less expected and traditional pattern, which is found also in the Semitic documents of the same character, their translation, except in the more complicated cases, is not too difficult. It is the contents of these tablets which give us a relatively full and accurate picture of the social and economic structure of Sumerian life in the third millennium B.C. Moreover the large quantity of onomastic material to be found in these economic documents furnishes a fruitful source for the study of the ethnic distribution in and about Sumer during this period.

Of the Sumerian inscriptions that are not economic in character, one group consists of approximately six hundred building and dedicatory inscriptions on steles, bricks, cones, vases, etc.

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stacked high in drawer after drawer; it is difficult to estimate their number, but it may be close to one hundred thousand.

[16] It is a curious fact that of all the expeditions excavating in Sumer in the course of the past century, the only one which uncovered Sumerian literary material in large quantity was that conducted by the University of Pennsylvania at Nippur. Relatively little has been excavated in the other sites of Sumer. No doubt this unfortunate fact is merely a matter of archaeological accident, the excavators evidently failed to come upon the temple and palace libraries. *From the point of view of the spiritual and religious history of the Sumerians as well as from that of Sumerian literature, the site that holds most promise to the future excavator is Eridu.* As the seat of the cult of Enki, the Sumerian "Lord of Wisdom", the keeper of the divine decrees which helped to found and govern Sumerian civilization, it should prove to be a veritable storehouse of literary and religious tablets.

It is from this relatively small group of inscriptions that the political history of Sumer has been largely recovered. The translation of these inscriptions, too, offers no great difficulties, since the contents are usually brief and simple. Moreover, the structure and pattern of the Sumerian dedicatory inscriptions are followed to a large extent by the later Semitic building inscriptions; the bilingual material, too, is of considerable help. All in all, therefore, except in the more complicated cases, the Sumerian historical material is relatively simple to translate and interpret.

The most significant material for the study of Sumerian culture, however, especially in its more spiritual aspect, consists of a group of approximately three thousand "literary" tablets and fragments dated about 2000 B.C. which are inscribed with Sumerian epics and myths, hymns and lamentations, proverbs and words of wisdom. Of these three thousand pieces, approximately nine hundred are distributed as follows: Some three hundred very tiny fragments have been found in Kish and were published by De Genouillac in 1924. Approximately two hundred pieces were bought by the Berlin Museum from dealers; these were published by Zimmern in 1912 and 1913. Approximately one hundred were bought by the Louvre from dealers; these were published by De Genouillac in 1930. Less than a hundred pieces have found their way to the British Museum and the Ashmolean Museum and have been published by King, Langdon, and Gadd. To these must be added an uncertain number (two hundred (?)) of tablets and fragments excavated recently in Ur which will be published by Gadd of the British Museum in the near future.

The remaining two thousand and one hundred tablets and fragments, by far the major part of our source material, was excavated by the University of Pennsylvania at Nippur almost fifty years ago. Of this number, over one hundred have found their way to the University of Jena in Germany, approximately eight hundred are located in the Museum of the Ancient Orient at Istanbul, *and almost eleven hundred are located in the University Museum at Philadelphia*. Of this Sumerian literary material lying in the University Museum, approximately four hundred pieces have been copied and published by a number of scholars in the course of the past four decades. It is the remaining six hundred and seventy-five pieces in the University Museum, which, with the aid of a grant from the American Philosophical Society, I have sought out and begun to copy. It will take some years to complete the copying of this large quantity of source material; its achievement will enable us to reconstruct and translate a large and significant group of Sumerian literary compositions. It is well worth noting that these Sumerian literary creations are significant not only for their remarkable form and illuminating contents. They are quite unique, too, in that they have come down to us as actually written by the scribes of four thousand years ago, unmodified and uncodified by later redactors with axes to grind and ideologies to satisfy. *Our Sumerian literary compositions thus represent the oldest literature of any appreciable and significant amount ever uncovered.*

Excursus B

Sumerian Epics and Myths

Undoubtedly one of the major significant and enduring humanistic achievements of the past hundred years consists of the discovery and decipherment of the Babylonian literary compositions inscribed on tablets that have lain buried in the ruins of Assyria and Babylonia for more than twenty-five hundred years. Inscribed in the Semitic Accadian language and in the cuneiform script, both of which had been unknown and forgotten for a period of two thousand years, the decipherment and translation of of these compositions was so rapid that their contents are now available to the layman as well as the scholar. The *Creation Epic*, the *Gilgamesh Epic*, the myth of *Ishtar's Descent to the Nether World*, to name but three of the better known compositions, are now listed and cited, quoted and analyzed in all the major works on mythology and religion. The men responsible for this achievement, Smith and Pinches, Schrader and Delitzsch, King and Thompson, Haupt and Jensen, to name some of the major figures, have gained lasting and well-earned recognition in the humanistic hall of fame.

As the decipherment and translation of the Babylonian literary compositions progressed, however, a strange phenomenon became increasingly apparent. A closer analysis of the poems revealed that while the language was Semitic, while the form and redaction were Semitic, while, too, the tone and temper, the overtones and undertones, were Semitic in character, the contents themselves clearly be-

trayed their Sumerian origin. For in practically all the Babylonian compositions, many of the major protagonists bear Sumerian, not Semitic, names. Thus, of the deities involved in the epics and myths, by far the greater number belong to the Sumerian pantheon. Gilgamesh, the great Babylonian hero, bears a Sumerian name. His father bears the Sumerian name Lugalbanda, his mother is the Sumerian goddess Ninsun. His friend and companion bears the good Sumerian name Enkidu. The facts and proofs lie clear and on the surface, it required no particular profundity, no extraordinary insight, to realize that the Babylonian compositions are of Sumerian origin.

What prevented scholars from effectively drawing this obvious conclusion is the fact that almost nothing was known of any *Sumerian* literary compositions. By the beginning of our century, the political history of the Sumerians had gradually been recovered, largely through the efforts of the very eminent French Assyriologist, Thureau-Dangin. The economic and administrative documents of the Sumerians, excavated by the hundreds of thousands, were being published and zealously studied. But the literary creations of the Sumerians continued to remain practically unknown. And yet there was no dearth of source material. Almost three thousand Sumerian literary tablets and fragments dating from the early post-Sumerian [17] period, *i.e.* from approximately 2000 B.C. and antedating the Babylonian Semitic compositions by more than a millennium, were lying in the store rooms of the European and American museums. In Nippur alone, the University of Pennsylvania had excavated over two thousand tablets and fragments which were divided between the Museum of the Ancient Orient at Istanbul and the University Museum at Philadelphia. The British Museum, the Louvre, and the Berlin Museum had obtained between them more than seven hundred Sumerian literary tablets and fragments, largely from the hands of dealers. To repeat, therefore, there was no dearth of source material.

What then hampered and impeded the decipherment of the Sumerian literary compositions? Why has so little progress been made in the reconstruction and translation of their contents? Primarily this unfortunate situation is due to the fact that only a small fraction of this source material has been copied and published to date. Tablets, and especially those inscribed with the Sumerian literary compositions, which are largely unbaked, rarely come out whole from the ground. Usually they are in a fragmentary, and not infrequently in a very fragmentary, state. Offsetting this disadvantage is the fact that the ancient scribes made more than one copy of any given composition. The breaks in one tablet may therefore frequently be restored from duplicating pieces which may themselves be in a very fragmentary condition. In the case of *Inanna's Descent to the Nether World*, for example, I utilized fourteen different fragments. In the case of the *Lamentation Over the Destruction of Ur* which I recently published, the text was reconstructed from twenty-two different fragments. In reconstructing one of the Ninurta epics (*cf.* No. 7 on p. 321) I utilized *forty-five* different fragments. To take full advantage of these duplications and the consequent restorations, however, it is essential to have as much as possible of the source material available. But of the Nippur literary tablets and fragments excavated by the University of Pennsylvania, over two thousand in number, only about five hundred have been copied and published to date. And while all of the approximately seven hundred pieces in the British Museum, Louvre, and Berlin Museum, have now been published, some of the more important texts did not appear until a relatively recent date. Under these circumstances, the reconstruction and translation of the Sumerian literary compositions on any major scale, were obviously impossible.

But even in case of the material long copied and published, the attempted translations were rarely scientific and trustworthy. In the first place, the translator was hampered by grammatical difficulties. For Arno Poebel's *Grundzüge der Sumerischen Grammatik*, the work that is now generally conceded to be the first and as yet only trustworthy attempt to place Sumerian grammar on a scientific basis, did not appear

[17] Very little literary material belonging to the Sumerian period proper, *i.e.* to the third millennium B.C., has been unearthed to date. No doubt this is a matter of archaeological accident, it is still lying underground in the excavated and unexcavated mounds of Sumer. The mound of Eridu especially may be expected to yield to the future excavator large quantities of this invaluable literary material dating from the Sumerian period. The major part of our present source material for the reconstruction of the Sumerian literary compositions, however, was written, though not necessarily composed, by the Semitic scribes of the early post-Sumerian period for whom Sumerian was the classical literary and religious language.

before 1923. Until then the translation of the Sumerian unilingual material was, grammatically speaking, largely a matter of guess work. The *Grundzüge*, however, is conceived and written from a logical rather than a pedagogical approach. Moreover, the principles laid down in it presuppose a thorough understanding of the Sumerian system of writing, a subject upon which the book barely touches. Consequently it presented so many difficulties to its readers that not a few failed to realize its significance and value, the more so since it proved to be no simple matter to apply the grammatical laws to the actual texts. In the course of the past decade this situation has been eased to no small extent by Poebel's more explicit studies and, if I may be permitted to say so, by my own efforts at clarification. While obviously enough many a point still remains obscure, the problem of Sumerian grammar can on the whole be rightly described as adequately settled.

In the second place, the translator was met by many lexical difficulties; indeed at the present moment the lexical problem is far more serious than the grammatical. One of the major sources for Sumerian lexicology consists of the bilingual texts where the Sumerian words are translated into Accadian. But a large number of words found in the Sumerian literary texts still have no Accadian equivalents. On the other hand many of them have, or at least seem to have, more than one Accadian equivalent. In these cases, the difficulties involved in the choice of the correct equation are not infrequently disastrous; a wrong choice may color falsely an entire context.[18]

In view of these difficulties, textual, grammatical and lexical, it is, therefore, profoundly gratifying to be in a position to announce after almost four years of continuous research in the Museum of the Ancient Orient at Istanbul and in the University Museum at Philadelphia, *the reconstruction of the larger part of the contents of twenty-three Sumerian epics and myths*. In the Museum of the Ancient Orient I copied one hundred and seventy Sumerian tablets and fragments of which approximately thirty are epics and myths.[19] In the University Museum, after examining the entire Nippur collection consisting of fifteen thousand tablets, I succeeded in cataloguing approximately one thousand and seventy-five pieces which contain Sumerian literary compositions dating from the early post-Sumerian period. About four hundred of these have been copied and published in the course of the past several decades by Poebel, Radau, Myhrman, Lutz, Barton, Langdon, Legrain, and especially by the late Edward Chiera. The remaining six hundred and seventy-five pieces, it is hoped, will be copied by me in the course of the coming several years. Of these six hundred and seventy-five pieces, approximately one hundred and seventy-five are epics and myths, three hundred are hymns, fifty are lamentations, and the remaining one hundred and fifty are proverbs and "wisdom" texts. In the past year my efforts were concentrated on the epics and myths. By utilizing all the extant published material together with the part of the unpublished material which I copied in the Museum of the Ancient Orient at Istanbul and *all* the unpublished pieces in the University Museum at Philadelphia,[20] the following epics and myths can now be reconstructed in large part:

Epics

1. *Enmerkar.*—Two large portions of an epical composition dealing with the exploits of this Sumerian hero in the course of subjugating the city of Aratta to Erech, can now be reconstructed from twenty-five published and unpublished texts. The larger portion consists of approximately three hundred and fifty, and the smaller portion of one hundred and fifty, consecutive

[18] The situation is complicated and worsened by the fact that we still lack a trustworthy Sumerian lexicon. The entire problem of Sumerian lexicology and lexicography is the subject of a forthcoming paper by the writer.

[19] Approximately 500 "literary" tablets and fragments from Nippur still remain uncopied in the Museum of the Ancient Orient. The copying of this material which must of course await the end of the war, will help to restore many of the passages now missing. Thus in the course of the very last days of my stay in Istanbul I discovered a large prism, excellently preserved, whose text when copied should restore almost completely the Enmerkar epic (No. 1 on p. 320).

[20] It is to be noted that to date only a part of the unpublished one hundred seventy-five tablets and fragments inscribed with Sumerian epics and myths, have been copied by me. Those pieces utilized in the reconstruction of the epics and myths which have not been copied, have been very carefully transliterated. The publication of each of the epics and myths, consisting of the hitherto unpublished original cuneiform text together with a transliteration, translation and commentary—the present publication of *Inanna's Descent to the Nether World* furnishes an excellent illustration of the method to be followed—will appear, it is hoped, in the course of the coming several years.

lines; in both cases the lines are about half complete.

2. *Lugalbanda and Enmerkar.*—The contents of this composition, hitherto usually designated *Lugalbanda and the Zu-bird* may be briefly sketched as follows. Lugalbanda, desirous of journeying to Aratta, is anxious to learn the divine instructions. He goes to Mt. Sabu and wilily succeeds in befriending the Zu-bird who knows the decisions of the gods and advises Lugalbanda accordingly. The latter now returns to Erech, whose king Enmerkar is in desperate straits. For fifty years the Martu have been ravaging all Sumer and Accad, and now Erech is in danger of falling. He was therefore seeking desperately some messenger who would journey to Aratta all alone and inform his sister Inanna of his dire plight. Lugalbanda volunteers for the task and succeeds in carrying Enmerkar's message to Inanna of Aratta, and in obtaining from her the appropriate instructions for the solution of Enmerkar's difficulties.

3. *Lugalbanda and Mt. Hurrum.*—Hitherto largely unknown, this tale narrates the adventures of Lugalbanda and his companions who had set out for an expedition to Mt. Hurrum, the same mountain where his son Gilgamesh later kills the monster Huwawa. Close to three hundred lines can now be reconstructed, half of which are complete.

4. *Gilgamesh and Agga of Kish.*—This tale consists of one hundred and fifteen lines, all practically complete. Briefly sketched, the story runs as follows: Agga, the king of Kish, has sent messengers to Gilgamesh demanding that Erech acknowledge the overlordship of Kish. Gilgamesh thereupon gathers a council of the elders of Erech and urges upon them the refusal of Agga's demands. Erech is then besieged by Agga and his warriors, and Gilgamesh is forced to acknowledge Agga as king of Erech.

5. *Gilgamesh and Huwawa.*—The first part of the composition consists of one hundred and seventy-eight lines, all almost perfectly preserved; it is reconstructed from twelve published and unpublished texts. It differs considerably in tone and contents from the traces of the Huwawa episode in the Semitic version of the Gilgamesh epic. The story runs as follows: Gilgamesh had set his heart to journey to the k u r - l ú - t i - l a , perhaps the mountain of immortality. He tells Enkidu of his determination, and the latter advises him to acquaint the sun god Utu of his project, since he is the builder of the mountain. Thereupon Gilgamesh offers prayers and sacrifices to Utu who helps him cross the seven mountains. At this point Enkidu urges Gilgamesh to abandon his dangerous undertaking, since the mountain is guarded by the fierce monster Huwawa. Gilgamesh refuses to consider Enkidu's advice and continues his journey. He comes upon Huwawa and begins to attack him. But Huwawa breaks into tears and pleads with Gilgamesh for mercy. Gilgamesh is inclined to listen to his plea but Enkidu advises against it. Gilgamesh and Enkidu then bring Huwawa before Enlil and Ninlil. (Here the extant part of the story unfortunately comes to an end.)

6. *Gilgamesh, Enkidu, and the Nether World.*—This composition consists of approximately three hundred lines of which about two hundred are in perfect condition; it is reconstructed from sixteen different fragments. The first half has been published by me under the title *Gilgamesh and the Huluppu-tree*; the latter half duplicates almost verbatim the twelfth tablet of the Semitic version of the *Gilgamesh Epic.*

7. *The Feats and Exploits of Ninurta.*—This epic, usually referred to as l u g a l - e - u_4 - m e - l á m - b i - n i r - g á l , consists of approximately six hundred and forty lines of which about four hundred are practically complete; it is reconstructed from forty-five texts of which more than half are still unpublished. It is this composition which was probably utilized in large part by the Semitic scribes in redacting their *Creation Epic.* Roughly the contents may be divided into four parts: 1. Ninurta, with the insistent advice and encouragement of his weapon the Sharur, attacks and destroys Kur, probably the Sumerian equivalent of the Accadian monster Tiamat. 2. He builds the Hursag and appoints the goddess Ninmah as its queen (hence her name Ninhursag). 3. He blesses and curses the stones. 4. He is praised and exalted for his heroic deeds.

8. *The Return of Ninurta to Nippur.*—This is the much shorter composition usually referred to as a n - g i m - d í m - m a ; it is reconstructed from twelve fragments. It treats largely of Ninurta's return to Nippur after he had vanquished the monster Kur and of the exaltation of his temple Eshumedu.

9. *Inanna and Entiki.*—Hitherto largely unrecognized, this tale narrates of the struggle of Inanna with Entiki, probably another name for Kur. It consists of one hundred and ninety

lines of which approximately one hundred are in perfect condition and is reconstructed from twelve fragments, largely unpublished.

Myths

1. *The Deluge.*—The tablet published by Poebel in HGT No. 1 still remains the only extant text for this important myth; neither in Istanbul nor in Philadelphia have I succeeded in uncovering any additional material.

2. *Enki and Ninhursag.*—This is the so-called and largely misinterpreted *Sumerian Epic of Paradise.* It consists of two hundred and seventy-six lines and its contents are truly remarkable for their simplicity and uniqueness. They may be briefly sketched as follows: 1. Enki sees to it that holy Dilmun is well supplied with water. 2. He begets Uttu, a female deity largely responsible for the earth's vegetation. 3. He is cursed by the goddess Ninhursag after decreeing the fate of numerous plants. 4. He is healed by Ninhursag who creates numerous deities for that purpose.

3. *Enlil and Ninlil.*—A fascinating myth in explanation of the birth of the moon-god Nanna and of the three chthonic deities, Nergal, Ninazu and one whose name is illegible; its one hundred and fifty-two lines of text are almost complete.

4. *Emesh and Enten.*—Hitherto practically unknown, this agricultural myth consisting of three hundred and eight lines of which approximately half are complete, is reconstructed from five fragments; four of these are still unpublished. Emesh and Enten are two demigods created by Enlil. Enten is appointed as the e n g a r - z i, "the trustworthy field worker" of Enlil, but Emesh disputes his title until finally Enlil is forced to intervene in favor of Enten. In the course of Enten's argument with Emesh he interpolates a prayer for the welfare of Ibi-Sin, the last of the kings of Ur.

5. *Lahor and Ashnan.*—Only one hundred and forty-five lines of this myth are as yet available; these are reconstructed from nine published and unpublished texts. The extant portion treats of the creation of the two cultural beings in charge of grain and cattle, and their descent to the earth at the command of Enlil and Enki.

6. *Enki and Ninmah.*—A very important myth dealing with the creation of man. The extant part consists of one hundred and thirty-one lines, most of which are fairly complete.

7. *Enki and Sumer.*—A myth treating largely of the civilizing of Sumer by Enki who appoints numerous cultural deities to their respective duties. Approximately two hundred and sixty-five lines can now be reconstructed of which about half are fairly complete.

8. *Enki and Eridu.*—This myth consisting of one hundred and twenty-eight lines can now be completely restored from twenty-one different fragments. It describes the building of Enki's temple at Eridu and of his trip to Nippur where he is welcomed by Enlil who blesses his handiwork.

9. *The Creation of the Pickax.*—This composition, too, can now be completely reconstructed; it consists of one hundred and eight lines based on twenty different fragments. It treats of the creation of the a l, "the pickax", by Enlil, and of its dedication by the gods.

10. *The Pickax and the Plow.*—About two hundred and twenty-two lines of this hitherto almost unknown composition can now be reconstructed from ten fragments; about half of the lines are fairly complete. The extant portion describes a colloquy between the two implements, each extolling its particular virtues. (It is not impossible, therefore, that the composition may turn out to be a fable rather than a myth.)

11. *Inanna's Descent to the Nether World.*—*Cf.* pages 295–312 of this publication.

12. *Inanna and Enki* or *The Transfer of Civilization from Eridu to Erech.*—This is one of the largest and most significant myths in the entire group. It consists of eight hundred and nineteen lines, about six hundred of which are complete. It is reconstructed from the large text published by Poebel in HGT No. 25, from PBS I 1, No. 1 (a text whose copy is quite untrustworthy and which I have therefore carefully collated), and from an unpublished fragment discovered and copied by me in Istanbul, which supplies the motivating link in the story. Inanna goes to the Abzu in order to obtain for her city Erech the divine decrees governing the approximately one hundred cultural controls and objects which go to make up the warp and woof of Sumerian civilization. At a feast arranged for her by Enki, she succeeds in inducing him to present all the m e, "divine decrees" to her; she loads them on the "Boat of Anu" and makes ready to depart for Erech. When Enki recovers from the effects of the banquet, however, he rues his munificence and decides to prevent Inanna from reaching

Erech. Seven times he attempts to have the boat and its precious cargo brought back to Eridu, but each time Inanna is saved by Anu's messenger Ninshubur. In spite of Enki's efforts she arrives in Erech safe and sound and is extolled and glorified by the people of the city for her feat.

13. *The Journey of Sin to Nippur.*—This composition consists of more than three hundred lines, more than half of which are complete. Sin journeys to Nippur with many gifts for his father Enlil. He is welcomed by the latter who grants him in return all that is essential to the welfare and prosperity of Ur.

14. *The Marriage of Martu.*—Published by Chiera in SEM No. 58, this tablet is still unduplicated; neither in Istanbul nor in Philadelphia have I been able to locate any additional material. The myth, one of the most charming of the group, deals with the marriage of Martu to the daughter of Numushda, the main deity of Kazallu.

PLATE 1

Ni 368. obv.

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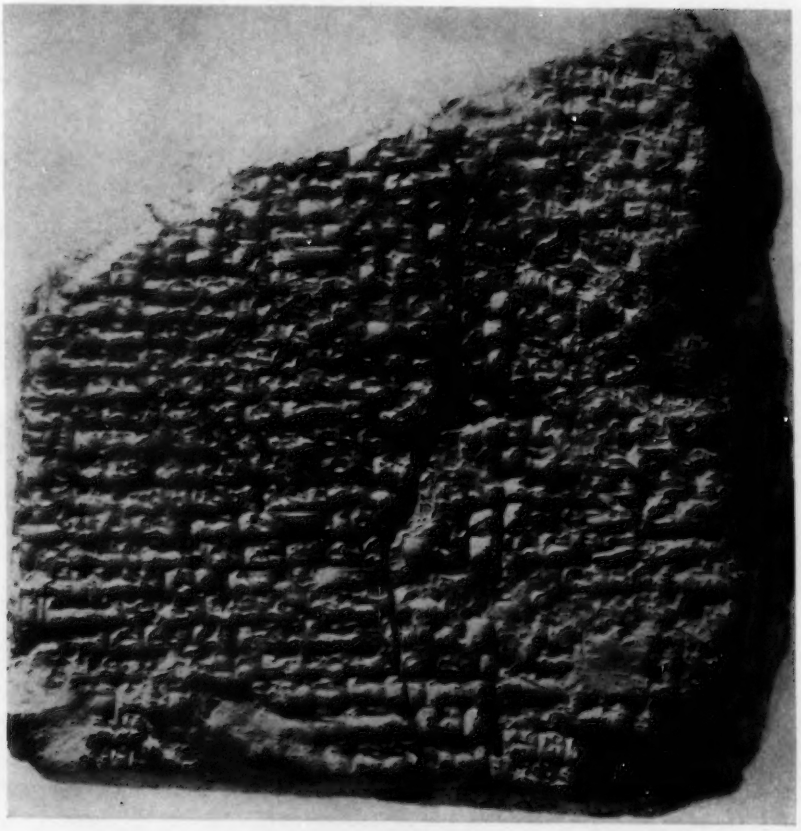

PLATE 2

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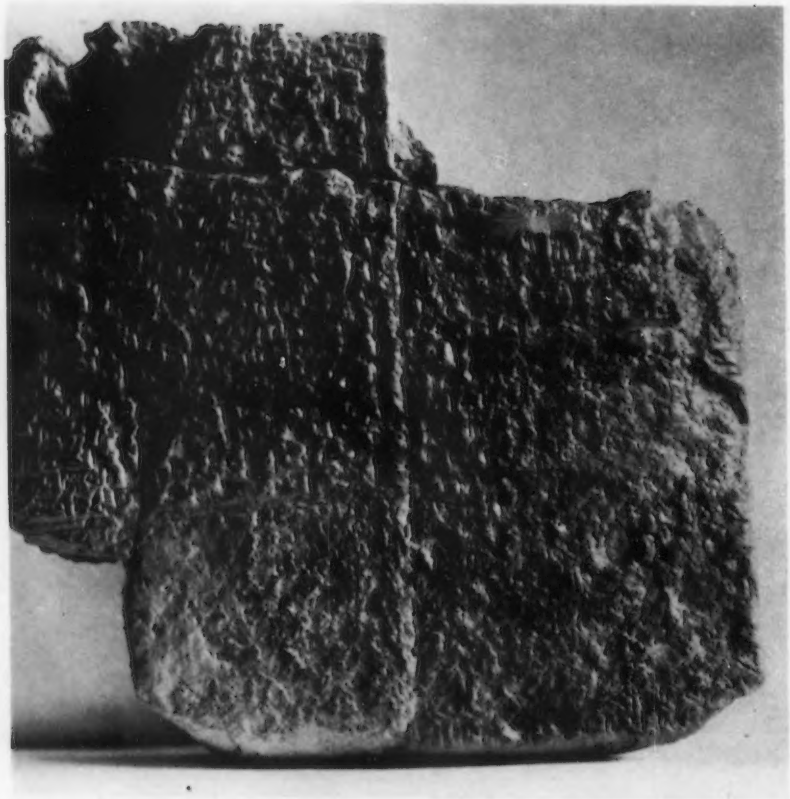

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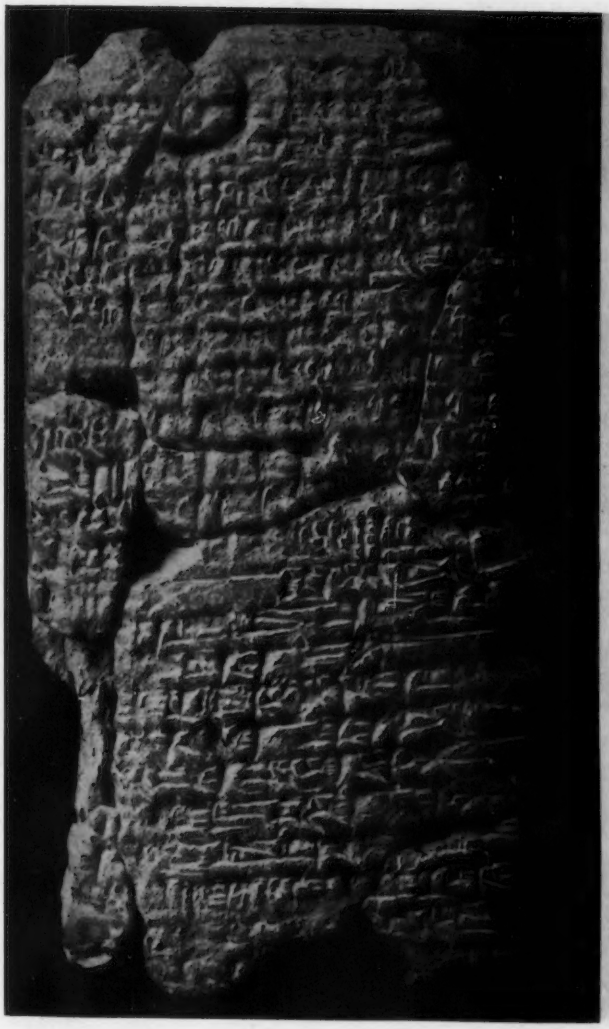

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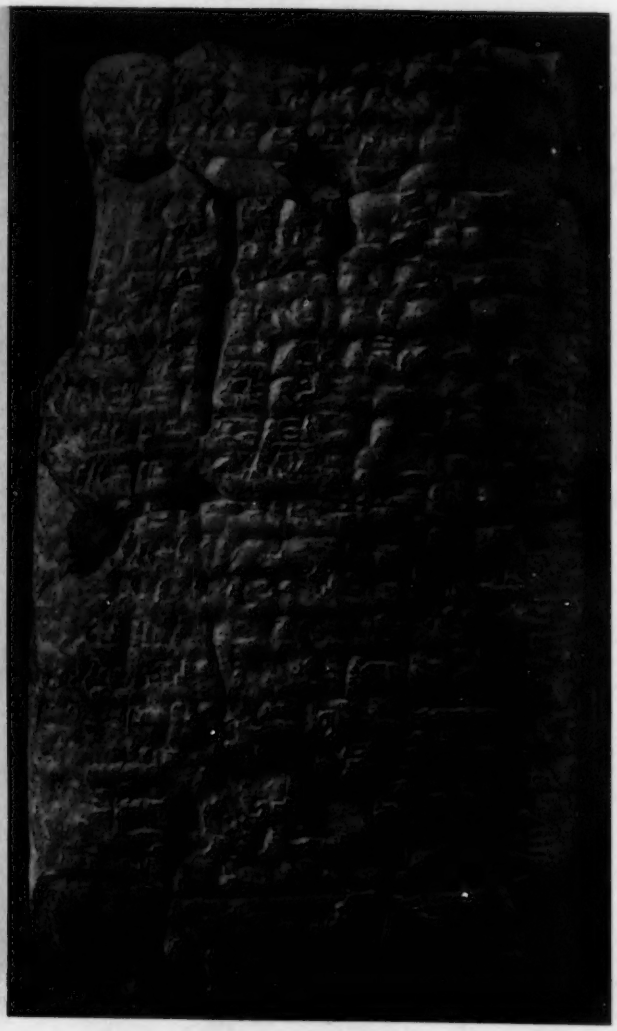

PLATE 4

CBS 12368 + 12702 + 12752.

obv. rev.

PLATE 5

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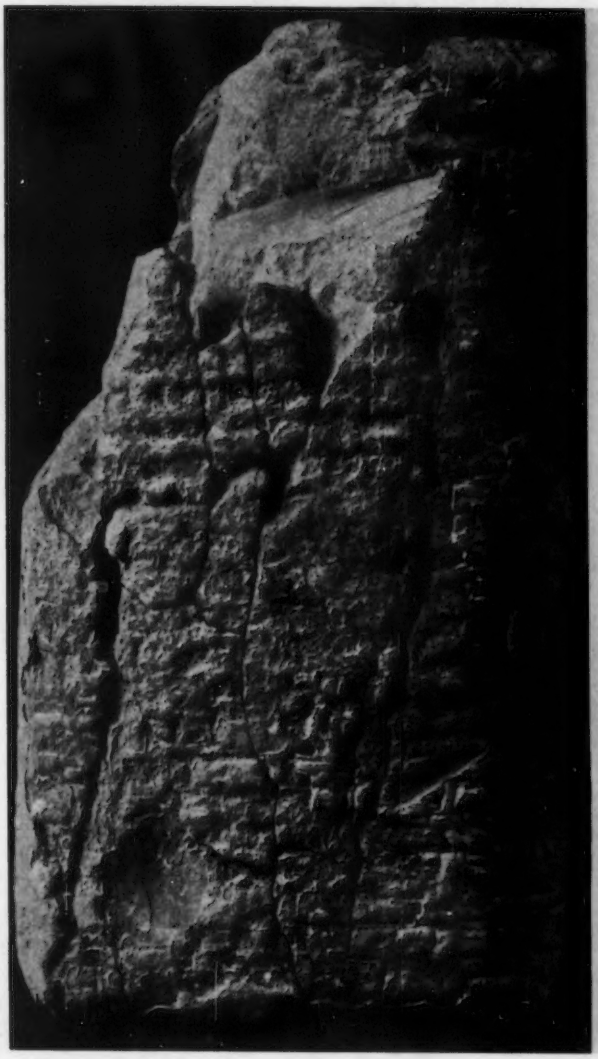
obv.



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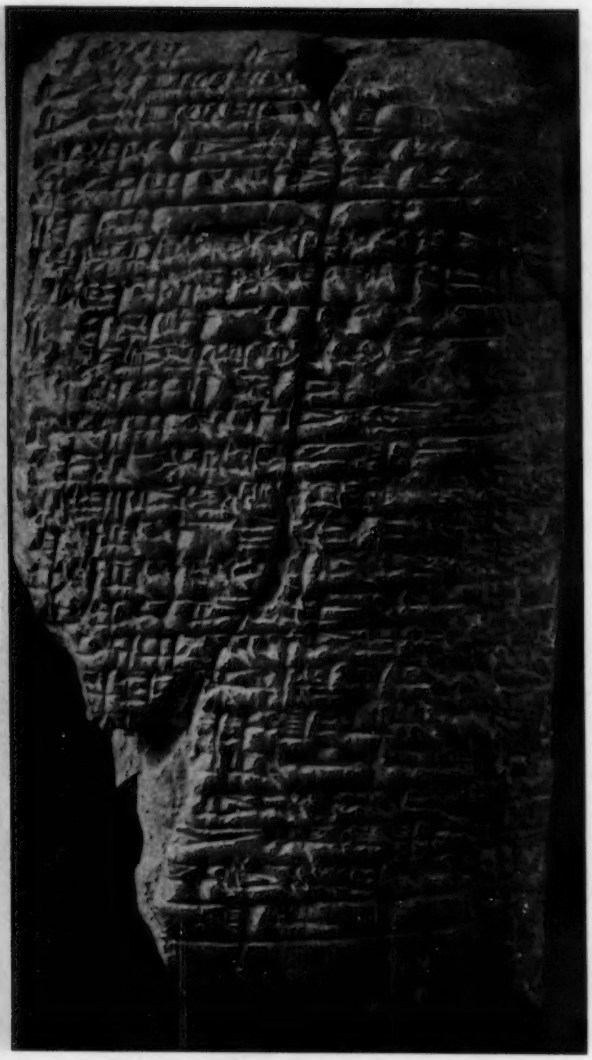


PLATE 6

C B S 11064 + 11088.

obv. rev.

PLATE 7

CBS 15212.

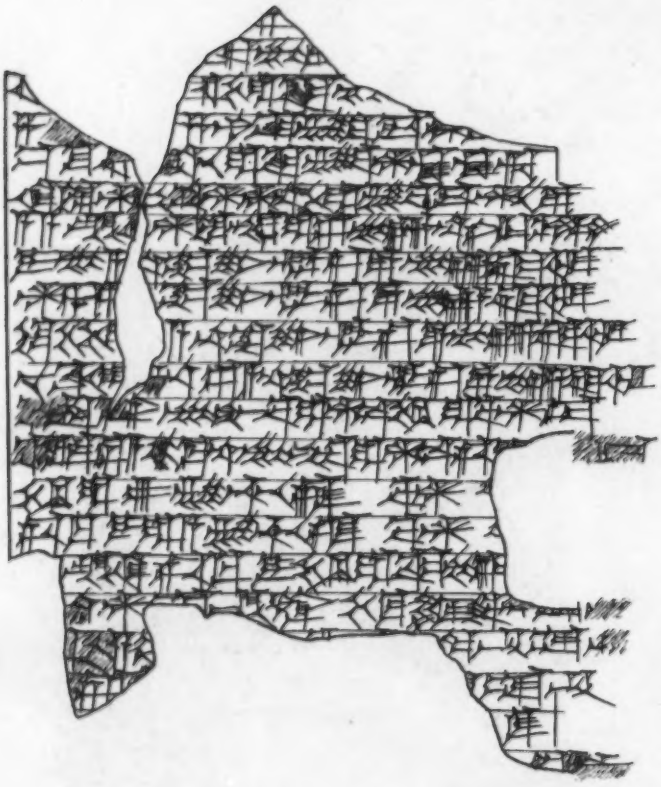
obv.

rev.

PLATE 8

Ni 4200.

obv.



rev.

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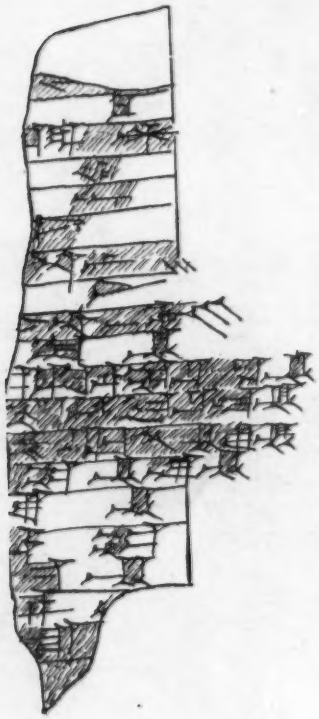

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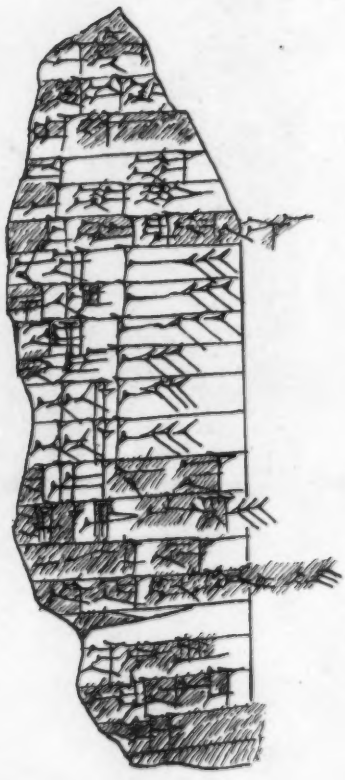


PLATE 9

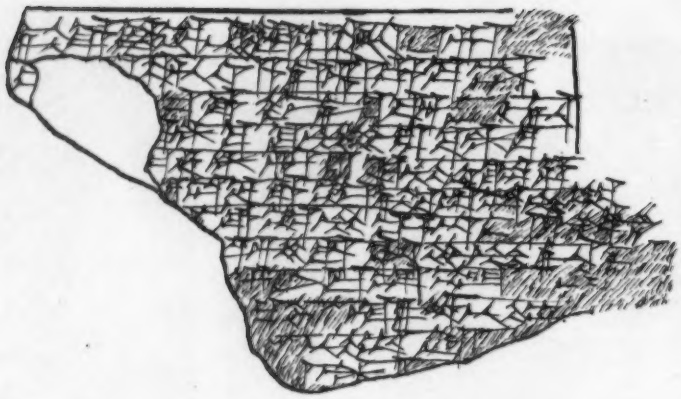
C B S 13902.

obv. rev.

PLATE 10

CBS 15162.

obv.



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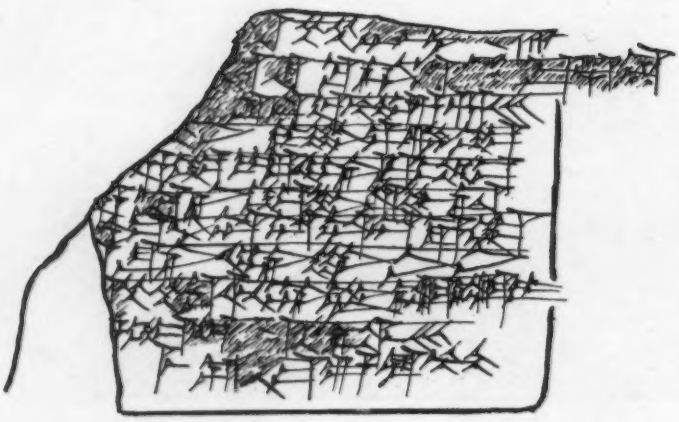
rev. destroyed

rev.



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